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

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Manuscripts

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3 **1 Prevalence, associated factors, treatment, and control of hypertension among adults in**
4 **2 rural Sylhet district of Bangladesh**
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3 **Abstract:**
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7 **Objectives:** All low- and middle-income countries are undergoing epidemiological transition,
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9 however, the progression is varied. Bangladesh is simultaneously experiencing a continuing
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11 burden of communicable diseases and an emerging burden of non-communicable diseases
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13 (NCDs). For effective use of limited resources, an increased understanding of the shifting burden
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15 and better characterization of risk factors of NCDs including hypertension is needed to develop
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17 scalable public health programs. This study provides data on prevalence, awareness, control of
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19 and associated factors of hypertension among males and females of 35 years and older in rural
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21 Bangladesh.
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28 **Methods:**
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30 This is a population based cross-sectional study conducted in Zakiganj and Kanaighat sub-
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32 districts of Sylhet district of Bangladesh. Blood pressure was measured and data on risk factors
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34 were collected using STEPS instrument from 864 males and 946 females aged 35 years and older
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36 between August 2017 and January 2018. Bivariate and multivariate analyses were performed to
37
38 identify factors associated with hypertension.
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45 **Results:** The prevalence of hypertension was 18.9% and 18.0% in adult males and females,
46
47 respectively. Among those who were hypertensive, the prevalence of controlled, uncontrolled
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49 and unaware/newly identified hypertension were 23.3%, 25.8% and 50.9%, respectively among
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51 males and 39.4%, 24.1% and 36.5%, respectively among females. Another 22.2% males and
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53 18.9% females had pre-hypertension. Increasing age and higher waist circumference (≥ 80 cm)
54
55 were positively associated with hypertension both in males and females.
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3 51 **Conclusions:** In view of the high burden of hypertension and pre-hypertension, a scalable public
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5 52 health program including behavior change, identification and management of hypertension needs
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8 53 to be developed and implemented.
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10
11 54 **Strengths and limitations of this study**
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14 55 • This is a study of prevalence and associated factors of hypertension in a representative
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16 56 population-based sample of adult males and females aged 35 years and older in a rural
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18 57 district of Bangladesh. To our knowledge, this study is the first to provide precise
19
20 58 estimates of hypertension and associated factors for a rural district in Bangladesh.
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22
23 59 • Blood pressure was measured using a standardized method and data on factors associated
24
25 60 with hypertension was collected using WHO STEPs questionnaire.
26
27 61 • The cross-sectional nature of the study limits the ability to establish causal relationship
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29 62 between the observed factors and hypertension.
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32 63 • Blood pressure was measured at the field level, not in a clinic setting. However, our
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34 64 workers were adequately trained and had years of experience measuring blood pressure in
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36 65 the field setting.
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49 71 **Keywords:** Hypertension, Bangladesh, Cross sectional study.
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72 INTRODUCTION

73 Each year an estimated 41 million people die from non-communicable diseases (NCDs)
74 accounting for about 70% of all deaths globally¹. Hypertension is one of the most common
75 NCDs. According to the Global Burden of Disease (GBD) reports, there has been a shift in
76 disease burden between 1990 and 2010 from communicable diseases to NCDs^{1,2}. This was most
77 notable in South Asia and sub-Saharan Africa regions, where a substantial proportion of the
78 world's population reside and where high blood pressure has had a particularly large effect on
79 disease burden². Globally, high blood pressure was the 4th leading risk factor for GBD in 1990,
80 as quantified by disability adjusted life years (DALYs); it ranked as the leading risk factor in
81 2010². About one out of four adults around the world have hypertension and it is projected to
82 increase to 29.2% by 2025, which will be more than 1.5 billion people worldwide³⁻⁵.

83 Uncontrolled hypertension increases the risks of cardiovascular disease, strokes, and end-
84 stage renal failure⁶. It accounts for about 45% of deaths due to ischemic heart disease and 52%
85 of deaths due to stroke⁶. Older age, high body mass index (BMI), unhealthy diet, lack of
86 physical exercise, smoking tobacco products, and family history of hypertension are major risk
87 factors for hypertension^{7,8}.

88 The prevalence of hypertension is increasing, primarily in low- and middle-income
89 countries (LMICs) and remain steady or decreasing in high-income countries (HICs)³. In South
90 Asia, the prevalence of hypertension is approximately 33% among people aged 18 years and
91 older with a secular trend documenting that the burden of hypertension is increasing over time⁹.
92 South Asia region accounts for 23% (or an estimated 258 million) of global hypertension burden
93⁹. An increase in hypertension prevalence in South Asia including Bangladesh could be attributed
94 largely to modifiable behavioral risk factors such as unhealthy diet, sedentary lifestyle, excess

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3 95 weight, tobacco consumption, alcohol abuse, and chronic stress including aging and urbanization
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5 96 ¹⁰⁻¹².

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8 97 Bangladesh, like many other LMICs, is undergoing an epidemiologic transition and an
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10 98 increased understanding of the burden and risk factors of hypertension is necessary to combat the
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12 99 increasing burden ¹³. However, data on burden and risk factors of hypertension from Bangladesh
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14 100 is limited. A nationally representative survey conducted in 2011 suggests that the prevalence of
15
16 101 hypertension including undiagnosed and uncontrolled hypertension in Bangladeshi adults is high
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18 102 ¹⁴⁻¹⁸. The available data is not adequate to provide regional or district level estimates. In view of
19
20 103 the increasing burden of NCDs, we have conducted this study in a rural district of Bangladesh
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22 104 where we have been working for about two decades to develop scalable public health programs
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24 105 by identifying priority health problems and by designing and testing interventions. Our work on
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26 106 newborn and reproductive health have influenced national and global policies ¹⁹⁻²².

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30
31 107 The study was designed to provide data on prevalence, awareness, control of and
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33 108 associated factors of hypertension among adults 35 years and older in our population with the
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35 109 aim of developing public health programs to prevent and control hypertension for a low resource
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37 110 setting with weak health system like Bangladesh.

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41 42 112 **METHODS**

43 44 113 **Study design and setting**

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47 114 This was a population-based cross-sectional study conducted between August 2017 and January
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49 115 2018 in an established field research site in Zakiganj and Kanaighat sub-districts of Sylhet
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51 116 district of Bangladesh. The site is maintained by a research partnership of the Johns Hopkins
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53 117 University, Baltimore, Maryland, USA, the Bangladesh Ministry of Health and Family Welfare,

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2
3 118 and Bangladeshi non-governmental organizations. The study area is in the north-east part of
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5 119 Bangladesh adjacent to the Indian states of Assam and Meghalaya. The study site is about 300
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7 120 kilometers away from Dhaka, the capital city of Bangladesh. Every village and household in the
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9 121 area are numbered. All married women of reproductive age have two numbers, a current
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11 122 identification number (CID) to locate the individual on the ground and a permanent identification
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13 123 number (PID) allowing longitudinal linkages. We maintain a basic demographic surveillance
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15 124 system which has been described previously²³⁻²⁵. The database of all individuals including their
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17 125 date of birth and sex constituted the sampling frame.
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23 127 **Sample Size**

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25 128 Sample size was estimated to measure the prevalence of hypertension separately for adult males
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27 129 and females 35 years and older in the study population. Conservatively assuming a hypertension
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29 130 prevalence of 10% in both males and females, a $\pm 2\%$ precision, and a significance level of 5%,
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31 131 the estimated sample size was 865 in each group. The sample size was inflated to 1,020 in each
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33 132 group to account for a 15% refusal or absence. This sample size allows us to detect a 5%
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35 133 difference in the prevalence of hypertension between males and females.
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41 135 **Study Population and implementation**

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43 136 Individuals either a male or female aged 35 year and older with a PID were eligible to participate
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45 137 in the study. Pregnant women were excluded. Participants were randomly selected from the
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47 138 database using automated procedures. They were visited in their homes by trained community
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49 139 health workers (CHWs) with a minimum of 10th grade education, who were already collecting
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51 140 routine surveillance and other study specific data, including blood pressure measurement of
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3 141 pregnant women^{26 27}. Given cultural sensitivities, two male CHWs were recruited to collect data
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5 142 from male participants. All CHWs received study specific training.
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8 143 Upon obtaining informed consent, CHWs administered an adapted version of the WHO's
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10 144 expanded STEP instrument at the participant's home^{28 29}. The instrument contained questions
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12 145 on NCD behavioral risk factors, including dietary habit, tobacco consumption, and physical
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14 146 activity. Data on other co-variates (e.g., household socio-economic status, education, occupation)
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16 147 were collected.
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19 148 After completing the household survey, CHWs measured blood pressure (BP) in mm Hg
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21 149 using digital BP machine (OMRON 5 Series®, model: BP742N). The digital machines were
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23 150 calibrated fortnightly by a physician against a gold standard mercury sphygmomanometer.
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26 151 Three measurements of both systolic and diastolic blood pressure were taken at approximately
27
28 152 5-minute intervals. All measurements were recorded in a data form and the average of the three
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30 153 measurements was used for this analysis. During measurements, the study participant remained
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32 154 seated with legs uncrossed and back and arm supported. The cuff was placed above the left
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34 155 elbow at the level of chest. In addition, CHWs obtained measurements of weight (in kilograms),
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36 156 height (in centimeter), waist circumference (in centimeter), hip circumference (in centimeter)
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38 157 and mid upper arm circumference (MUAC, in centimeter) of the study participants using
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40 158 standardized methods.
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46 160 **Measurements**

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49 161 Blood pressure was classified as normal, pre-hypertension, or hypertension, based on criteria
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51 162 used in the World Health Organization-International Society of Hypertension (WHO-ISH)³⁰. A
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53 163 participant was considered to have normal blood pressure if systolic blood pressure (SBP) was
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3 164 <120 mm Hg and the diastolic blood pressure (DBP) <80 mm Hg and not taking
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5 165 antihypertensive drugs. An SBP of 120-139 mmHg or a DBP of 80-89 mmHg with no history of
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7 166 taking antihypertensive medication during survey was classified as prehypertension. A
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10 167 participant was considered having hypertension if the SBP was ≥ 140 mmHg or DBP was ≥ 90
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12 168 mmHg or the blood pressure was below these cut-offs, but the study participant reported taking
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14 169 antihypertensive medication. Controlled hypertension was defined as an SBP <140 mmHg and a
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16 170 DBP <90 mmHg and reported use of antihypertensive medication during survey. A SBP of ≥ 140
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18 171 mmHg or a DBP ≥ 90 mmHg in a study participant taking antihypertensive medication was
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20 172 considered as uncontrolled hypertension. An individual with SBP ≥ 140 mm Hg or DBP ≥ 90 mm
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22 173 Hg with no history of taking antihypertensive medication was considered as newly identified or
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24 174 unaware of hypertension. The participants with high measured BP were referred to the hospital
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26 175 for further evaluation and care.

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31 176 Participants' were categorized based on age into four groups (35-44, 45-54, 55-64, and
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33 177 ≥ 65 years old). We calculated body mass index (BMI) as the ratio of weight in kilograms to
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35 178 height in meters squared (weight in kg/height in m^2) and categorized using the WHO-
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37 179 recommended cutoff points: underweight (<18.5 kg/m^2), normal (18.5 – 24.9 kg/m^2), and
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39 180 obese/overweight (≥ 25.0 kg/m^2)³¹. Household wealth scores were created using a principal
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41 181 components analysis of individual housing materials and household possessions³² and
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43 182 categorized into wealth tertiles. We used STEPS instrument to collect data on risk and protective
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45 183 factors. The data on fruits and vegetables intake were combined and categorized into <2 servings
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47 184 per day, 2-4 servings per day and ≥ 5 servings per day. Participants were defined as a current
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49 185 smoker if they reported smoking cigarettes, cigars, or pipes during the survey. Similarly,
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51 186 participants were defined as a current smokeless tobacco user if reported using smokeless
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3 187 tobacco products such as snuff, chewing tobacco leaf, *goul*, *noshi* or *zarda* at the time of the
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5 188 survey. Based on participants' reported work related vigorous and moderate activities including
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7 189 duration of the activities, we categorized these variables into; no vigorous/moderate physical
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10 190 activity, <30 min vigorous/moderate physical activity and ≥ 30 min vigorous/moderate physical
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12 191 activity.
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16 193 **Data analysis**

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18 194 We presented percent distribution of selected sociodemographic and other factors including
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20 195 median and interquartile range for continuous variables for the total sample as well as separately
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22 196 for males and females. We calculated the prevalence and 95% confidence intervals (CI) of
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24 197 hypertension, pre-hypertension, controlled, uncontrolled and unaware or newly identified
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26 198 hypertension using WHO-ISH guidelines³⁰. Bivariate and multivariable logistic regression were
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28 199 used to identify factors significantly associated with hypertension separately for males and
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30 200 females. First, we conducted bivariate logistic regression analysis. Variables with a p-value of
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32 201 <0.1 in the bivariate analyses were included in the multivariable logistic regression model. As a
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34 202 priori, we included smoking, fruits and vegetables and physical activities variables in the
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36 203 multivariable model for females even they were not significant in the bivariate model. Data was
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38 204 analyzed using Stata version 15 (StataCorp 2015).
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43 205 We obtained approval from the National Research Ethics Committee of the Bangladesh
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45 206 Medical Research Council (BMRC) and the Institutional Review Board (IRB) of the Johns
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47 207 Hopkins Bloomberg School of Public Health, USA to conduct the research.
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212 RESULTS

213 We approached 1,020 males and 1,019 females aged 35 years or older (total of 2,039) for study
 214 participation. Among the 1,020 males, 29 (2.8%) refused participation, 49 (4.8%) were absent
 215 and 76 (7.5%) were excluded for other reasons. Among the 1,019 females, 7 (0.7%) refused, 7
 216 (0.7%) were absent, 14 (1.4%) were excluded because they were pregnant, and 45 (4.4%) were
 217 excluded for other reasons. Of the 1,810 participants who completed the survey, 864 were male
 218 and 946 were female. Distributions of sociodemographic and lifestyle characteristics of male,
 219 female and all participants are presented in Table 1.

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

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

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

¹: column percentage; IQR: interquartile range

The median ages of male and female participants were 50 (IQR 42, 60) years and 47 (IQR 40, 57) years, respectively. The median BMI of males and females were 20.1 (IQR 18.2, 22.5) and 20.5 (IQR 18.0, 23.3) kg/m², respectively. Among females, 17.2% were overweight/obese and 42.7% had high waist circumference (≥ 80 cm). Majority of the males (63.2%) reported smoking currently compared to 3.8% of the females who did so. About 14.5% males and 10.5% females reported intake of ≥ 5 servings of fruits and vegetables per day. Among males, 17.1% reported ≥ 30 min work related vigorous-intense activities compared to 3.0% females who reported the same. About half (53.2%) of males and 16.3% females reported ≥ 30 min work related moderate-intense activities (Table 1).

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

236 identified hypertension was 23.3%, 25.8% and 50.9%, respectively among males and 39.4%,
 237 24.1% and 36.5%, respectively among females (Table 2 and figure 1). Another 22.2% of the
 238 males and 18.9% of the females were pre-hypertensive.

239

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

Blood pressure categories	Males	Females	Total
	N= 864	N=946	N=1,810
	%, 95% CI	%, 95% CI	%, 95% CI
Normal blood pressure¹	58.8, 55.6-62.2	63.1, 60.0-66.1	61.0, 58.8-63.3
Pre-hypertension²	22.2, 19.6-25.1	18.9, 16.5-21.5	20.5, 18.7-22.4
Hypertension³	18.8, 16.0-22.0	18.0, 16.0-21.0	18.4, 17.0-20.0
	n= 163	n=170	n=333
Controlled⁴	23.3, 17.1-30.6	39.4, 32.0-47.2	31.5, 26.6-36.5
Uncontrolled⁵	25.8, 19.2-33.1	24.1, 17.9-31.3	24.9, 20.4-29.3
Newly identified⁶	50.9, 43.0-58.8	36.5, 29.2-44.2	43.5, 38.1-49.2

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256 not taking antihypertensive medication; ²SBP 120-139 mm Hg or DBP 80-89 mm Hg and not taking
 257 antihypertensive medication; ³SBP \geq 140 mm Hg or DBP \geq 90 mm Hg or taking antihypertensive medication; ⁴SBP
 258 <140 mm Hg and DBP < 90 mm Hg but taking antihypertensive medication; ⁵SBP \geq 140 mm Hg or DBP \geq 90 mm
 259 Hg and taking antihypertensive medication; ⁶SBP \geq 140 mm Hg or DBP \geq 90 mm Hg and not taking
 260 antihypertensive medication.

261

262 Simple and multivariable logistic regression analyses to investigate factors associated

263 with hypertension are presented in Table 3.

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

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

12

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

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

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

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3 276 In the adjusted logistic regression model, we included waist circumference but not BMI
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5 277 because they were highly correlated ($r = .83$). In the adjusted analysis, among males, age older
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7 278 than 45 years and waist circumference ≥ 80 cm was positively and reported vigorous-intensity
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9 279 activities was inversely related to risk of hypertension. Among females, older age, higher
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11 280 socioeconomic status and waist circumference ≥ 80 cm was positively related with risk of
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13 281 hypertension (table 3). The odds of hypertension were increasing significantly as the age was
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15 282 increasing both in males (45-55 y: adjusted odds ratio [aOR] 1.7, 95% CI: 1.0-3.0; 55-64 y: aOR
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17 283 2.9, 95% CI 1.6-5.2, 65+ y: aOR 3.1, 95% CI 1.7-5.4) and in females (45-55 y: aOR 2.3, 95% CI
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19 284 1.4-3.7, 55-64 y: aOR 3.0, 95% CI 1.7-5.4, 65+ y: aOR 6.0, 95% CI 3.5-10.3). The odds of
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21 285 hypertension were three-folds higher among both males (aOR 3.7, 95% CI 2.5-5.6) and females
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23 286 (aOR 2.9, 95% CI 2.0-4.2) with the waist circumference ≥ 80 cm. In a subsequent adjusted
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25 287 model, we replaced waist circumference by BMI; overweight/obese was significantly associated
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27 288 with greater odds of hypertension in both males (aOR 2.7, 95% CI 1.7-4.7) and females (aOR
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29 289 1.8, 95% CI: 1.2-2.9) (data not shown).

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291 **DISCUSSION**

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

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3 298 The data on prevalence of and risk factors for hypertension in Bangladesh is limited. The
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5 299 Bangladesh Demographic and Health Survey 2011 (BDHS-2011) measured blood pressure in a
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8 300 nationally representative sample of adult males and females ¹⁶. The BDHS estimates of
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10 301 hypertension prevalence for Sylhet division were similar to our finding among males but was
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12 302 higher (25.2%) among females. However, the BDHS Sylhet prevalence rate for females was
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14 303 based on 232 women with a wide confidence interval (19.6-31.1). BDHS documented a
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16 304 substantial urban versus rural and regional variations. The urban sample had a much higher
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19 305 prevalence than the rural sample (40.2% vs 29.4%). Among eight divisions (regions) of
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21 306 Bangladesh, Sylhet division where the current study was conducted, had the lowest prevalence
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23 307 (25.2%) ¹⁶. Our findings of prevalence of hypertension in females is similar (18.4% vs 18.0%)
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26 308 but higher in males (13.5% vs 18.8%) in a study conducted in a rural area in Bangladesh ³³.

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29 309 Our findings of positive associations between hypertension and potential risk factors such
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31 310 as age, BMI, and waist circumference are consistent with several studies from Bangladesh and
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33 311 elsewhere ^{17 18 34}. A dose response relationship was observed between the risk of hypertension
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36 312 and age, the risk increased with the increase of age; highest risk was observed in the oldest age
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38 313 groups among both males and females ^{18 35}.

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40 314 High BMI is an established risk factor for hypertension ¹⁵; several studies found that
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42 315 overweight/obesity had the strongest association with hypertension ^{33 36 37}. Body weight is the
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44 316 balance between consumption and expenditure of energy. One would expect higher calorie
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47 317 consumption among higher SES group. Adult males and females with a waist circumference of
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49 318 ≥ 80 cm had 4 and 3 folds higher risks of hypertension, respectively compared to those with a
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52 319 waist circumference < 80 cm. Both BMI and waist circumference are established risk factors for
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55 320 hypertension. In our study, we analyzed them separately but presented waist circumference data

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3 321 instead of BMI because several studies suggested that abdominal fat deposition is generally a
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5 322 stronger predictor of hypertension than BMI-based association^{38 39}. Moreover, we chose waist
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7 323 circumference in our model instead of BMI because it can be easily measured and programs can
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10 324 use it for screening.

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12 325 Several studies observed an association between hypertension and higher socio-economic
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14 326 status^{33 40}. In our study, we observed a positive association of hypertension among females;
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17 327 women who belonged to higher wealth groups were twice as likely to have hypertension
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19 328 compared to those who belonged to the poorest wealth group. Recent interventional studies
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21 329 showed beneficial effects of exercise on blood pressure reduction^{41 42}. We observed a lower risk
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24 330 among males who reported vigorous intense activities for ≥ 30 minutes. The odds of having
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26 331 hypertension was 60.0% less among males those who had reported vigorous-intense activities.
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31 333 We did not see a protective effect of fruit or vegetable consumptions on hypertension in
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33 334 our population. In this poor agrarian community most people consume vegetables every day, the
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35 335 quantity might be low. Fruit consumption is low among rural Bangladeshi people. Seasonal
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37 336 fruits are grown in abundance but are not popular because people do not consider them as good
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39 337 fruit⁴³. Imported fruits are costly and remain unaffordable to many people leading to a very low
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42 338 consumption of fruit⁴³. The benefit of fruits and vegetable consumption is primarily through
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44 339 increased intake of potassium^{44 45}. All vegetables may not contain high level of potassium and
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46 340 washing, and cooking may reduce potassium level⁴⁶. In this study, we did not see a higher risk
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49 341 among smokers. Not seeing a benefit of fruit and vegetable consumptions or not seeing an
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51 342 increased risk among smokers could be due to reverse causation i.e., those with hypertension
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3 343 might have modified their behavior but that is unlikely because about half of those hypertensive
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5 344 were newly diagnosed.
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9 346 The study has several limitations. The cross-sectional nature of the study limits the ability
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11 347 to establish causal relationship between the observed risk factors and hypertension. Also, the
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13 348 study was conducted in one region of Bangladesh and may not be generalizable for the entire
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15 349 country. We could not measure or collect data on all variables associated with hypertension. We
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17 350 defined hypertension by measuring blood pressure levels at the field level, not in a clinic setting.
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19 351 However, our workers were adequately trained and had years of experience measuring blood
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21 352 pressure in the field setting. We calibrated the blood pressure machines fortnightly against
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23 353 mercury sphygmomanometer. This survey used standard and pre-tested STEPs questionnaire to
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25 354 collect data from study participants.
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29 355 Our finding of high levels of hypertension in this rural area is important because the risk
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31 356 of CVDs is about 16 folds higher among those with hypertension compared to those with a SBP
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33 357 of <115 and DBP of <75 ⁴⁷. However, the risk of CVDs is higher for all individuals with a SBP
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35 358 >115 or DBP >75 ⁴⁷⁻⁴⁹. For every 10 mm increase in BP, the risk almost doubles. Although the
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37 359 risk is lower in the so-called normal BP groups compared to those with hypertension, since there
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39 360 are many more individuals in these BP categories, the burden of CVD related to hypertension
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41 361 among them is substantial. Therefore, efforts need to be made to identify and control
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43 362 hypertension and adopt strategies to reduce blood pressure of the entire population and prevent
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45 363 rise of BP with age.
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50 364 Our results show a high prevalence of hypertension and pre-hypertension in the surveyed
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52 365 population. In addition, high prevalence of newly diagnosed and uncontrolled hypertension
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54 366 despite the availability of low cost and safe drugs for hypertension is a major public health
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3 367 concern. Apart from age, the most important risk factor of hypertension is behavioral and
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5 368 potentially modifiable. For example, inappropriate diet and physical inactivity – resulting in high
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7 369 body mass index, raises blood pressure and unfavorable blood lipids – together with tobacco use,
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9 370 explain at least 75% of cardiovascular disease. Addressing behavioral risk factors, particularly
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11 371 unhealthy diet and physical inactivity can prevent hypertension. Salt reduction initiatives can
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13 372 make a major contribution to prevention and control of high blood pressure. However, vertical
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15 373 programs focusing on hypertension control alone are not cost effective⁵⁰. Integrated context
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17 374 specific program including behavior change, identification and management of hypertension
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19 375 needs to be designed implemented at scale through a primary health care approach. That will be
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21 376 an affordable and sustainable approach for countries to tackle the increasing burden of
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23 377 hypertension⁵⁰.
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39 383 investigator during implementation of the study in the field.
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44 385 **AUTHOR CONTRIBUTIONS**

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47 386 The study was designed, and analysis was conceptualized by Rasheda Khanam (RK) and
48
49 387 Abdullah H. Baqui (AHB). RK, AHB, Salahuddin Ahmed and Sayedur Rahman implemented
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51 388 the study. Syed Jafar Raza Rizvi and Sayed Mamun Ibne Moin managed the data. RK and
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3 389 Malathi Ram conducted data analysis. RK drafted the manuscript with support from AHB. All
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5 390 authors reviewed and provided feedback on the draft and approved the final manuscript.
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10 392 **COMPETING INTERESTS**

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12 393 All authors declare that they have no conflict of interest
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3 399 **Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist**
4 400 **circumference, Sylhet, Bangladesh**
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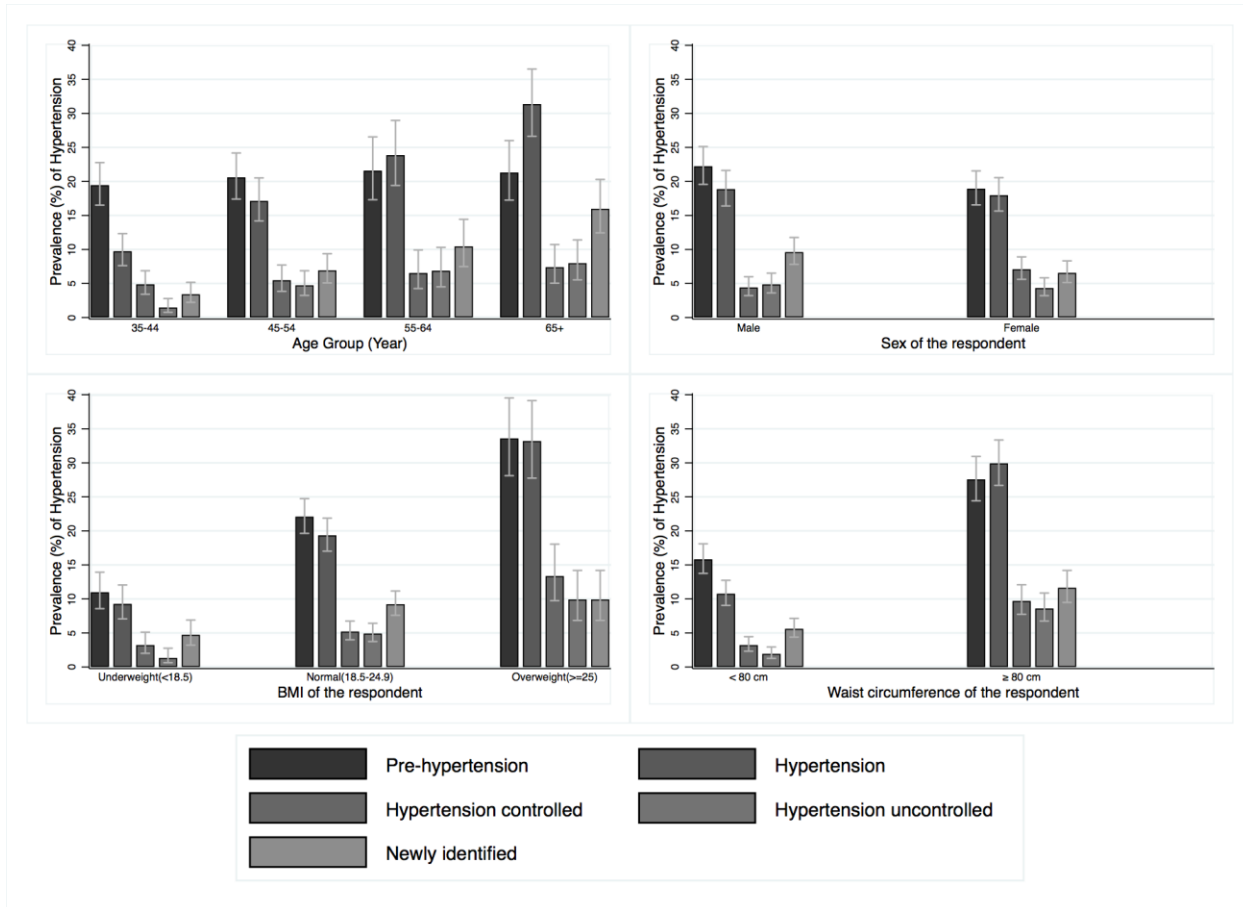


Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist circumference, Sylhet, Bangladesh

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

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

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

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4 *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.
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6 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE
7 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
8 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.
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BMJ Open

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

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3 **1 Prevalence and factors associated with hypertension among adults in rural Sylhet district**
4 **2 of Bangladesh: A cross-sectional study**
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8 4 Rasheda Khanam¹, Salahuddin Ahmed², Sayedur Rahman², Gulam Muhammed Al Kibria³, Syed
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10 George Pariyo¹, and Abdullah H. Baqui¹ for the Projahnmo Study Group in Bangladesh
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3 **27 Abstract:**
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5 **28 Objectives:** All low- and middle-income countries are undergoing epidemiological transition,
6
7 however, the progression is varied. Bangladesh is simultaneously experiencing a continuing
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9 burden of communicable diseases and an emerging burden of non-communicable diseases
10
11 (NCDs). For effective use of limited resources, an increased understanding of the shifting burden
12
13 and better characterization of risk factors of NCDs including hypertension is needed to develop
14
15 scalable public health programs. This study provides data on prevalence and factors associated
16
17 with hypertension among males and females 35 years and older in rural Bangladesh.
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21 **25 Methods:**
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24 This is a population based cross-sectional study conducted in Zakiganj and Kanaighat sub-
25
26 districts of Sylhet district of Bangladesh. Blood pressure was measured and data on risk factors
27
28 were collected using STEPS instrument from 864 males and 946 females aged 35 years and older
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30 between August 2017 and January 2018. Individuals with systolic blood pressure of ≥ 140 mmHg
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32 or diastolic blood pressure of ≥ 90 mmHg or taking antihypertensive drugs were considered
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34 hypertensive. Bivariate and multivariate analyses were performed to identify factors associated
35
36 with hypertension.
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39
40 **43 Results:** The prevalence and 95% confidence interval (CI) of hypertension was 18.8% (16.3-
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42 21.5) and 18.7% (16.3-21.3) in adult males and females, respectively. Among those who were
43
44 hypertensive, the prevalence of controlled, uncontrolled and unaware/newly identified
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46 hypertension were 23.5%, 25.9% and 50.6%, respectively among males and 38.4%, 22.6% and
47
48 39.0%, respectively among females. Another 22.7% males and 17.8% females had pre-
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50 hypertension. Increasing age and higher waist circumference (≥ 90 cm for males and ≥ 80 cm for
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52 females) were positively associated with hypertension both in males and females.
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3 50 **Conclusions:** In view of the high burden of hypertension and pre-hypertension, a context-
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5 51 specific scalable public health program including behavior change communications as well as
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7 52 identification and management of hypertension needs to be developed and implemented.
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11 53 **Strengths and limitations of this study**

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14 54 • The study provides primary data on prevalence and risk factors of hypertension for adult
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16 55 males and females from community-based samples of a low resource setting.
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18 56 • We used standard and validated STEPS instrument which is used widely allowing
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20 57 comparison of our data with data from other studies.
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22
23 58 • The cross-sectional nature of the study limits the ability to establish causal relationship
24
25 59 between the observed factors and hypertension.
26
27 60 • We could not measure all the potential risk factors for hypertension which could have
28
29 61 enhanced the interpretation.
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32 62 **Keywords:** Hypertension, Bangladesh, Cross sectional study.
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63 INTRODUCTION

64 Each year an estimated 41 million people die from non-communicable diseases (NCDs)
65 accounting for about 70% of all deaths globally ¹. Hypertension is one of the most common
66 NCDs. According to the Global Burden of Disease (GBD) reports, between 1990 and 2010, there
67 has been a shift in disease burden from communicable diseases to NCDs ^{1 2}. This was most
68 notable in South Asia and sub-Saharan Africa regions, where a substantial proportion of the
69 world's population reside and where high blood pressure has had a particularly large effect on
70 disease burden ². Globally, high blood pressure was the 4th leading risk factor for GBD in 1990,
71 as quantified by disability adjusted life years (DALYs); it ranked as the leading risk factor in
72 2010 ². About one out of four adults around the world have hypertension and it is projected to
73 increase to 29.2% by 2025, which will be more than 1.5 billion people worldwide³⁻⁵.

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

79 The prevalence of hypertension is increasing, primarily in low- and middle-income
80 countries (LMICs) and remain steady or decreasing in high-income countries (HICs) ³. In South
81 Asia, the prevalence of hypertension is approximately 33% among people aged 18 years and
82 older with a secular trend documenting that the burden of hypertension is increasing over time ⁹.
83 South Asia region accounts for 23% (or an estimated 258 million) of global hypertension
84 burden⁹. An increase in hypertension prevalence in South Asia including Bangladesh could be
85 attributed largely to modifiable behavioral risk factors such as unhealthy diet, sedentary lifestyle,

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3 86 excess weight, tobacco consumption, alcohol abuse, and chronic stress including aging and
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5 87 urbanization¹⁰⁻¹².
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8 88 Bangladesh, like many other LMICs, is undergoing an epidemiologic transition and an increased
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10 89 understanding of the burden and risk factors of hypertension is necessary to combat the
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12 90 increasing burden¹³. A nationally representative survey conducted in 2011 (BDHS-2011)
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14 91 suggests that the prevalence of hypertension including undiagnosed and uncontrolled
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16 92 hypertension in Bangladeshi adults is high¹⁴⁻¹⁸. However, the available data is not adequate to
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18 93 provide regional or district level estimates. We have conducted this study among adults 35 years
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20 94 and older in a rural district of Bangladesh where we have been working for about two decades to
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22 95 develop and implement a scalable intervention for hypertension.
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28 97 **METHODS**

30 98 **Study design and setting**

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33 99 This was a population-based cross-sectional study conducted between August 2017 and January
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35 100 2018 in an established field research site in Zakiganj and Kanaighat sub-districts of Sylhet
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37 101 district of Bangladesh. The site is maintained by a research partnership of the Johns Hopkins
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39 102 University, Baltimore, Maryland, USA, the Bangladesh Ministry of Health and Family Welfare,
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41 103 and Bangladeshi non-governmental organizations. The study site is located in the north-east part
42
43 104 of Bangladesh adjacent to the Indian states of Assam and Meghalaya, about 300 kilometers away
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45 105 from Dhaka, the capital city of Bangladesh. Every village and household in the area are
46
47 106 numbered. All married women of reproductive age have two numbers, a current identification
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49 107 number (CID) to locate the individual on the ground and a permanent identification number
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51 108 (PID) allowing longitudinal linkages. We maintain a basic demographic surveillance in our study
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3 109 area which include periodic census and updating of vital events (births, deaths and movements)
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5 110 by 2 monthly home visits ¹⁹⁻²¹. The database of all individuals including their date of birth and
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7
8 111 sex, constituted the sampling frame.
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10 112

11 113 **Sample Size**

12 114 Sample size was estimated to measure the prevalence of hypertension separately for adult males
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15
16 115 and females 35 years and older in the study population. Conservatively assuming a hypertension
17
18 116 prevalence of 10% in both males and females, a $\pm 2\%$ precision, and a significance level of 5%,
19
20 117 the estimated sample size was 865 in each group. Assuming a 15% refusal or absence, we
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22
23 118 selected 1,020 individuals in each group. This sample size allows us to detect a 5% difference in
24
25 119 the prevalence of hypertension between males and females.
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28 121 **Study Population and implementation**

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31 122 Individuals, either a male or female aged 35 year and older were eligible to participate in the
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34 123 study. Pregnant women were excluded. We recruited the study participants from the database
35
36 124 using computer generated random numbers. They were visited in their homes by trained
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39 125 community health workers (CHWs) with a minimum of 10th grade education, who were already
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41 126 collecting routine surveillance and other study specific data, including blood pressure
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43 127 measurement of pregnant women ^{22 23}. Given cultural sensitivities, two male CHWs were
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46 128 recruited to collect data from male participants. All CHWs received study specific training.
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48 129 Upon obtaining informed consent, CHWs administered an adapted version of the WHO's
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50 130 expanded STEP instrument at the participant's home ^{24 25}. The instrument contained questions
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53 131 on NCD behavioral risk factors, including dietary habit, tobacco consumption, and physical
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3 132 activity. Data on other co-variates (e.g., household socio-economic status, education, occupation)
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5 133 were collected.
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8 134 After completing the household survey, CHWs measured blood pressure (BP) in mmHg
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10 135 using digital BP machine (OMRON 5 Series®, model: BP742N). The digital machines were
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12 136 calibrated fortnightly by a physician against a gold standard mercury sphygmomanometer.
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15 137 We measured both systolic and diastolic blood pressure three times at approximately 10-minute
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17 138 intervals between measurements¹⁶. All measurements were recorded in a data form and the
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19 139 average of the last two measurements were used for this analysis. During measurements, the
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21 140 study participant remained seated with legs uncrossed and back and arm supported. We used two
22
23 141 different cuff sizes based on mid-upper arm circumference (MUAC) measurement. For
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25 142 participants with a MUAC of <22 cm, we used small cuff and for those with a MUAC of >22
26
27 143 cm, we used a medium cuff. The cuff was placed above the left elbow at the level of chest. In
28
29 144 addition, CHWs obtained measurements of weight (in kilograms), height (in centimeter), waist
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31 145 circumference (in centimeter), hip circumference (in centimeter) and mid upper arm
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33 146 circumference (MUAC, in centimeter) of the study participants using standardized methods.
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39 40 148 **Measurements**

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42 149 Blood pressure was classified as normal, pre-hypertension, or hypertension, based on criteria
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44 150 used in the World Health Organization-International Society of Hypertension (WHO-ISH)²⁶. A
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46 151 participant was considered to have normal blood pressure if systolic blood pressure (SBP) was
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48 152 <120 mmHg and the diastolic blood pressure (DBP) <80 mmHg and not taking antihypertensive
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50 153 drugs. An SBP of 120-139 mmHg or a DBP of 80-89 mmHg with no history of taking
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52 154 antihypertensive medication during survey was classified as prehypertension²⁷. A participant was
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3 155 considered having hypertension if the SBP was ≥ 140 mmHg or DBP was ≥ 90 mmHg or the
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5 156 blood pressure was below these cut-offs, but the study participant reported taking
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8 157 antihypertensive medication. Controlled hypertension was defined as an SBP < 140 mmHg and a
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10 158 DBP < 90 mmHg and reported use of antihypertensive medication during survey. A SBP of ≥ 140
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12 159 mmHg or a DBP ≥ 90 mmHg in a study participant taking antihypertensive medication was
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15 160 considered as uncontrolled hypertension. An individual with SBP ≥ 140 mmHg or DBP ≥ 90
16
17 161 mmHg with no history of taking antihypertensive medication was considered as newly identified
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19 162 or unaware of hypertension. The participants with high measured BP were referred to the
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22 163 hospital for further evaluation and care.

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24 164 Participants' were categorized based on age into four groups (35-44, 45-54, 55-64, and
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26 165 ≥ 65 years old). We calculated body mass index (BMI) as the ratio of weight in kilograms to
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28 166 height in meters squared (weight in kg/height in m^2) and categorized using the WHO-
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31 167 recommended cutoff points: underweight (< 18.5 kg/m^2), normal (18.5 – 24.9 kg/m^2), and
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33 168 obese/overweight (≥ 25.0 kg/m^2)²⁸. We categorized waist circumference into low risk (< 90 cm
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35 169 for males and < 80 cm for females) and high risk (≥ 90 cm for males and ≥ 80 cm for females). We
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38 170 created a household wealth score based on type of housing, source of drinking water, type of
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40 171 toilet, availability of electricity and household possessions as a measure of household economic
41
42 172 status, using the Principal Component Analysis (PCA)^{29 30}. The wealth index is a composite
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44
45 173 measure of a household's cumulative wealth that places individual household on a continuous
46
47 174 scale of relative wealth. We divided the households in to wealth tertiles .

48
49 175 We used STEPS instrument to collect data on risk and protective factors³¹. The data on
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51 176 fruits and vegetables intake were combined and categorized into < 2 servings per day, 2-4
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54 177 servings per day and ≥ 5 servings per day. Participants were defined as a current smoker if they
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178 reported smoking cigarettes, cigars, or pipes during the survey. Similarly, participants were
179 defined as a current smokeless tobacco user if reported using smokeless tobacco products such as
180 snuff, chewing tobacco leaf, *goul*, *noshi* or *zarda* at the time of the survey. We collected data on
181 physical activity (PA) across all domains including work, transportation (walking/biking) and
182 leisure- time/recreational activity. Data on time spent on PA were converted into minutes per
183 week and then we calculated metabolic equivalent task (MET)-minutes per week for all activities
184 combined³². According to standard classification, a MET-minute of <600 per week is classified
185 as low PA, 600-3000 MET-minutes is considered as moderate PA and >3000 MET-minutes is
186 considered as high PA. In our population, there was none with high PA. Based on distribution of
187 MET-minutes, we have categorized our population into very low PA (<300 MET-min/week),
188 low PA (300 to <600 MET-min/week) and moderate PA (>600 MET-min/week).

189

190 **Data analysis**

191 We presented percent distribution of selected sociodemographic and other factors including
192 median and interquartile range for continuous variables for the total sample as well as separately
193 for males and females. We calculated the prevalence and 95% confidence intervals (CI) of
194 hypertension, pre-hypertension, controlled, uncontrolled and unaware or newly identified
195 hypertension using WHO-ISH guidelines²⁶. Bivariate and multivariable logistic regression were
196 used to identify factors significantly associated with hypertension separately for males and
197 females. First, we conducted bivariate logistic regression analysis. Variables with a p-value of
198 <0.05 in the bivariate analyses were included in the multivariable logistic regression model. In
199 addition, we have added a few variables (smoking, consumption of fruits and vegetables and
200 physical activity) as a priori even if those variables were not statistically associated in bivariate

201 analysis because these variables have been shown to be associated with hypertension and there is
 202 biological basis for it. Data was analyzed using Stata version 15 (StataCorp 2015).

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

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

209 RESULTS

210 We approached 1,020 males and 1,019 females aged 35 years or older (total of 2,039) for study
 211 participation. Among the 1,020 males, 29 (2.8%) refused participation, 49 (4.8%) were absent
 212 and 76 (7.5%) were excluded for other reasons. Among the 1,019 females, 7 (0.7%) refused, 7
 213 (0.7%) were absent, 14 (1.4%) were excluded because they were pregnant, and 45 (4.4%) were
 214 excluded for other reasons. Of the 1,810 participants who completed the survey, 864 were male
 215 and 946 were female. Distributions of sociodemographic and lifestyle characteristics of male,
 216 female and all participants are presented in Table 1.

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

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

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

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

223 The median ages of male and female participants were 50 (IQR 42, 60) years and 47
 224 (IQR 40, 57) years, respectively. The median BMI of males and females were 20.1 (IQR 18.2,
 225 22.5) and 20.5 (IQR 18.0, 23.3) kg/m², respectively. Among females, 16.9% were
 226 overweight/obese and 42.5% had high waist circumference (≥80 cm). Majority of the males
 227 (63.2%) reported smoking currently compared to 3.8% of the females who did so. About 14.5%

228 males and 10.5% females reported intake of ≥ 5 servings of fruits and vegetables per day.

229 Majority of the males (57.8%) and most females (93.7%) reported very low PA. (Table 1).

230 The prevalence and 95% confidence interval of hypertension was 18.8% (16.3-21.5) in
 231 males and 18.7% (16.3-21.3) in females (Table 2). Among those with hypertension, the
 232 prevalence of controlled, uncontrolled and unaware/newly identified hypertension was 23.5%,
 233 25.9% and 50.6%, respectively among males and 38.4%, 22.6% and 39.0%, respectively among
 234 females (Table 2 and figure 1). Another 22.7% of the males and 17.8% of the females were pre-
 235 hypertensive.

236

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

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

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255 Notes: ¹SBP <120 mmHg and DBP <80 mmHg and not taking antihypertensive medication; ²SBP 120-
 256 139 mmHg or DBP 80-89 mmHg and not taking antihypertensive medication; ³SBP ≥ 140 mmHg or DBP
 257 ≥ 90 mmHg or taking antihypertensive medication; ⁴SBP <140 mmHg and DBP < 90 mmHg but taking
 258 antihypertensive medication; ⁵SBP ≥ 140 mmHg or DBP ≥ 90 mmHg and taking antihypertensive
 259 medication; ⁶SBP ≥ 140 mmHg or DBP ≥ 90 mmHg and not taking antihypertensive medication.

260 Simple and multivariable logistic regression analyses to investigate factors associated

261 with hypertension are presented in Table 3. In unadjusted logistic regression, the risk of

262 hypertension was higher among those older than 45 years, overweight/obese, and who had high

263 waist circumference (≥ 90 cm for males and ≥ 80 cm for females). The odds of hypertension were

264 lower in both males and females who were underweight. Among males, those who belonged to

265 the highest wealth tertile and among females who belonged to the middle and highest wealth
 266 tertiles had significantly higher odds of hypertension in unadjusted logistic regression. Among
 267 males, compared to those with very low PA, those with low and moderate PA had lower
 268 prevalence of hypertension (Table 3).

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

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

271 Notes: OR: odds ratio, CI: confidence interval, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$; ² For males, low risk is < 90 cm
272 and high risk is ≥ 90 cm and for females, low risk is < 80 cm and high risk is ≥ 80 cm

273 In the adjusted logistic regression model, we included waist circumference but not BMI
274 because they were highly correlated ($r = .68$). In the adjusted analysis, among males, age older
275 than 45 years and waist circumference ≥ 90 cm was positively and reported low and moderate PA
276 were inversely related to risk of hypertension (Table 3). Among females, older age, higher
277 socioeconomic status and waist circumference ≥ 80 cm was positively related with risk of
278 hypertension (Table 3). The odds of hypertension were increasing as the age was increasing both
279 in males (45-55 y: adjusted odds ratio [aOR] 1.3, 95% CI: 0.8-2.4; 55-64 y: aOR 3.0, 95% CI
280 1.7-5.4, 65+ y: aOR 3.5, 95% CI 2.0-6.3) and in females (45-55 y: aOR 2.3, 95% CI 1.5-3.8, 55-
281 64 y: aOR 3.1, 95% CI 1.7-5.4, 65+ y: aOR 5.7, 95% CI 3.4-9.5). The odds of hypertension were
282 four-folds higher among males (aOR 4.0, 95% CI 2.5-6.4) and three-folds higher among females
283 (aOR 2.9, 95% CI 2.1-4.1) with high waist circumference (≥ 90 cm in males and ≥ 80 cm in
284 females). In a subsequent adjusted model, we replaced waist circumference by BMI;
285 overweight/obese was significantly associated with greater odds of hypertension in both males
286 (aOR 3.1, 95% CI 1.8-5.3) and females (aOR 1.9, 95% CI: 1.2-2.9) (data not shown).

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288 DISCUSSION

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

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3 295 The data on prevalence of and risk factors for hypertension in Bangladesh is limited. The
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5 296 Bangladesh Demographic and Health Survey 2011 (BDHS-2011) measured blood pressure in a
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7 297 nationally representative sample of adult males and females¹⁶. The BDHS estimates of
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9 298 hypertension prevalence for Sylhet division were similar to our finding among males but was
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11 299 higher (25.2%) among females. However, the BDHS Sylhet prevalence rate for females was
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13 300 based on 232 women with a wide confidence interval (19.6-31.1). BDHS documented a
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15 301 substantial urban versus rural and regional variations. The urban sample had a much higher
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17 302 prevalence than the rural sample (40.2% vs 29.4%). Among eight divisions (regions) of
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19 303 Bangladesh, Sylhet division where the current study was conducted, had the lowest prevalence
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21 304 (25.2%)¹⁶. Our findings of prevalence of hypertension is similar in females (18.4% vs 18.7%)
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23 305 but higher in males (13.5% vs 18.8%) than in a study conducted among adults 25 years and older
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25 306 in 2005 in three rural areas of Bangladesh³³.

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27 307 Our findings of positive associations between hypertension and potential risk factors such
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29 308 as age, BMI, and waist circumference are consistent with several studies from Bangladesh and
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31 309 elsewhere^{17 18 34}. A dose response relationship was observed between the risk of hypertension
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33 310 and age, the risk increased with the increase of age; highest risk was observed in the oldest age
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35 311 groups among both males and females^{18 35}.

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37 312 High BMI is an established risk factor for hypertension¹⁵; several studies found that
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39 313 overweight/obesity had the strongest association with hypertension^{33 36 37}. Body weight is the
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41 314 balance between consumption and expenditure of energy. One would expect higher calorie
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43 315 consumption among higher SES group. Adult males and females with a higher waist
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45 316 circumference had four- and three-fold higher risks of hypertension, respectively. Both BMI and
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47 317 waist circumference are established risk factors for hypertension. In our study, we analyzed
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3 318 them separately but presented waist circumference data instead of BMI because several studies
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5 319 suggested that abdominal fat deposition is generally a stronger predictor of hypertension than
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7 320 BMI-based association^{38 39}. Moreover, we chose waist circumference in our model instead of
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9 321 BMI because it can be easily measured, and programs can use it for screening provided training
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11 322 is adequate.

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14 323 Compared to those who belonged to the poorest wealth group, we observed about a two-
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16 324 fold higher risk of hypertension among females but not among males who belonged to higher
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18 325 wealth groups. The association of socio-economic status with hypertension is not consistent
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20 326 across studies; some studies observed higher rate of hypertension among higher socioeconomic
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22 327 group and yet, other studies observed higher rate among the poor^{33 40 41}. A recent review reported
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24 328 an overall increased risk of hypertension among the lowest SES, particularly in high-income
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26 329 countries⁴¹.

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29 330 Association between PA and risk of hypertension are well documented. Interventional
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31 331 studies showed beneficial effects of PA on blood pressure reduction^{42 43}. Recreational PA is
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33 332 uncommon in our population (<1%). We observed a lower risk among males who reported PA
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35 333 for ≥ 300 MET minutes per week. Compared to those with very low PA, the odds of having
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37 334 hypertension was 40.0% and 70.0% less among males who had reported low and moderate PA
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39 335 respectively.

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42 336 We did not see a protective effect of fruit or vegetable consumptions on hypertension in
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44 337 our population. In this poor agrarian community most people consume vegetables every day, the
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46 338 quantity might be low. Fruit consumption is low among rural Bangladeshi people. Seasonal
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48 339 fruits are grown in abundance but are not popular because people do not consider them as good
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50 340 fruit⁴⁴. Imported fruits are costly and remain unaffordable to many people leading to a very low
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3 341 consumption of fruit ⁴⁴. The benefit of fruits and vegetable consumption is primarily through
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5 342 increased intake of potassium ^{45 46}. All vegetables may not contain high level of potassium and
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8 343 washing, and cooking may reduce potassium level ⁴⁷. In this study, we did not see a higher risk
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10 344 among smokers. Not seeing a benefit of fruit and vegetable consumptions or not seeing an
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12 345 increased risk among smokers could be due to reverse causation i.e., those with hypertension
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14 346 might have modified their behavior but that is unlikely because about half of those hypertensive
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17 347 were newly diagnosed.

18
19 348 The study has several limitations. The cross-sectional nature of the study limits the ability
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21 349 to establish causal relationship between the observed risk factors and hypertension. Also, the
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23 350 study was conducted in one region of Bangladesh and may not be generalizable for the entire
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25 351 country. The sample size is small, which limited risk factor analysis. We could not measure or
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27 352 collect data on all variables associated with hypertension. We defined hypertension by
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29 353 measuring blood pressure levels at the field level, not in a clinic setting. However, our workers
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31 354 were adequately trained and had years of experience measuring blood pressure in the field
32
33 355 setting. We calibrated the blood pressure machines fortnightly against mercury
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35 356 sphygmomanometer. This survey used standard and pre-tested STEPs questionnaire to collect
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37 357 data from study participants which is used widely allowing comparison of our data with data
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39 358 from other studies.

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42 359 Our finding of high rates of hypertension in this rural area is important because the risk of
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44 360 CVDs is about 16 folds higher among those with hypertension compared to those with a SBP of
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46 361 <115 and DBP of <75 ⁴⁸. However, the risk of CVDs is higher for all individuals with a SBP
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48 362 >115 or DBP >75 ⁴⁸⁻⁵⁰. For every 10 mm increase in BP, the risk almost doubles. Although the
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50 363 risk is lower in the so-called normal BP groups compared to those with hypertension, since there
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3 364 are many more individuals in these BP categories, the burden of CVD related to hypertension
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5 365 among them is substantial. Therefore, efforts need to be made to identify and control
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8 366 hypertension and adopt strategies to reduce blood pressure of the entire population and prevent
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10 367 rise of BP with age.

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12 368 Our results show a high prevalence of hypertension and pre-hypertension in the surveyed
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14 369 population. In addition, high prevalence of newly diagnosed and uncontrolled hypertension
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16 370 despite the availability of low cost and safe drugs for hypertension is a major public health
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18 371 concern. Apart from age, the most important risk factor of hypertension is behavioral and
19
20 372 potentially modifiable. For example, inappropriate diet and inadequate physical inactivity lead to
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22 373 overweight/obesity, raises blood pressure and increases unfavorable blood lipids. These factors
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24 374 together with tobacco use, explain at least 75% of cardiovascular disease. Addressing behavioral
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26 375 risk factors, particularly unhealthy diet and physical inactivity can prevent hypertension. Salt
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28 376 reduction initiatives can make a major contribution to prevention and control of high blood
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30 377 pressure. However, vertical programs focusing on hypertension control alone are not cost
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32 378 effective⁵¹. Integrated context specific program including behavior change and identification and
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34 379 management of hypertension needs to be designed and implemented at scale through a primary
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36 380 health care approach. That will be an affordable and sustainable approach for countries to tackle
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38 381 the increasing burden of hypertension⁵¹.

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390

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

399 **COMPETING INTERESTS**

400 All authors declare that they have no conflict of interest

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403 No additional data available.

404

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3 409 **Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist**
4 410 **circumference, Sylhet, Bangladesh**
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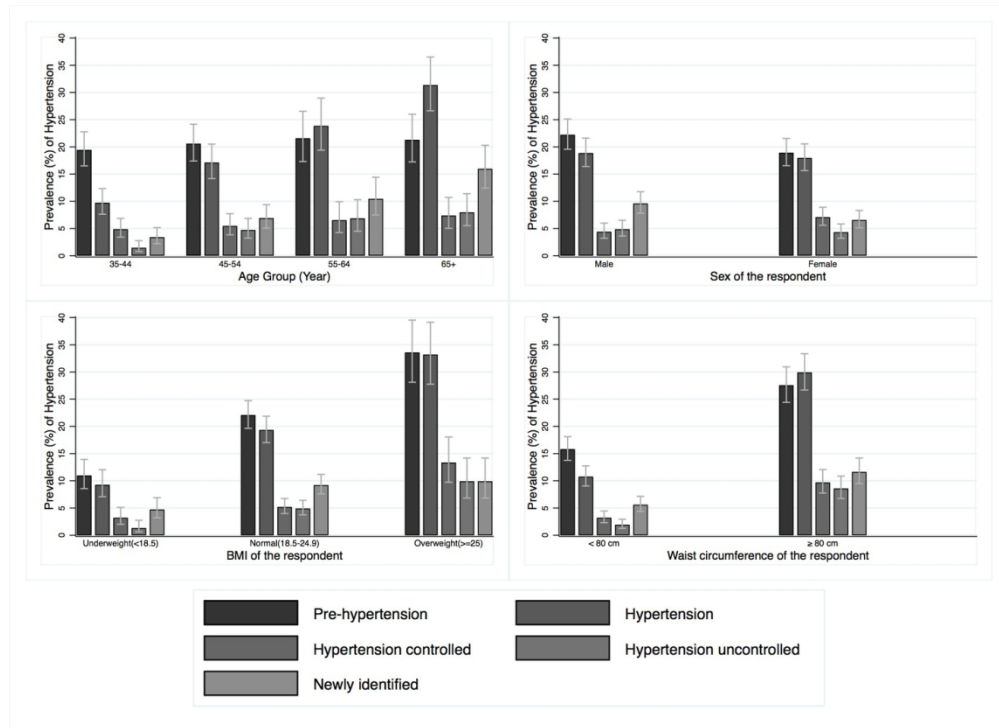


Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist circumference, Sylhet, Bangladesh

123x90mm (300 x 300 DPI)

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

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

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

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3 *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.
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6 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE
7 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
8 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.
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For peer review only

BMJ Open

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

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Primary Subject Heading:	Global health
Secondary Subject Heading:	Cardiovascular medicine, Epidemiology
Keywords:	Associated factors, Cross-sectional study, Bangladesh, Hypertension < CARDIOLOGY

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Manuscripts

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3 **1 Prevalence and factors associated with hypertension among adults in rural Sylhet district**
4 **2 of Bangladesh: A cross-sectional study**
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8 4 Rasheda Khanam¹, Salahuddin Ahmed², Sayedur Rahman², Gulam Muhammed Al Kibria³, Syed
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10 6 George Pariyo¹, and Abdullah H. Baqui¹ for the Projahnmo Study Group in Bangladesh
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3 **27 Abstract:**
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5 **28 Objectives:** Low- and middle-income countries are undergoing epidemiological transition,
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however, progression is varied. Bangladesh is simultaneously experiencing continuing burden of
communicable diseases and emerging burden of non-communicable diseases (NCDs). For
effective use of limited resources, an increased understanding of the shifting burden and better
characterization of risk factors of NCDs, including hypertension is needed. This study provides
data on prevalence and factors associated with hypertension among males and females 35 years
and older in rural Bangladesh.

35 **Methods:**

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

43 **Results:** The prevalence of hypertension was 18.8% (95% CI: 16.3-21.5) and 18.7% (95% CI:
44 16.3-21.3) in adult males and females, respectively. Among those who were hypertensive, the
45 prevalence of controlled, uncontrolled and unaware/newly identified hypertension was 23.5%,
46 25.9% and 50.6%, respectively among males and 38.4%, 22.6% and 39.0%, respectively among
47 females. Another 22.7% males and 17.8% females had pre-hypertension. Increasing age and
48 higher waist circumference (≥ 90 cm for males and ≥ 80 cm for females) were positively
49 associated with hypertension both in males (OR, 95% CI: 4.0, 2.5-6.4) and females (OR, 95%
50 CI: 2.8, 2.0-4.1).

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3 51 **Conclusions:** In view of the high burden of hypertension and pre-hypertension, a context-
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5 52 specific scalable public health program including behavior change communications, particularly
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7 53 to increase physical activity and consumption of healthy diet, as well as identification and
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9 54 management of hypertension needs to be developed and implemented.
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14 55 **Strengths and limitations of this study**

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16 56 • The study provides primary data on prevalence and associated factors of hypertension for
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18 57 adult males and females from community-based samples of a low resource setting.
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20 58 • We used standard and validated STEPS instrument which is used widely allowing
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22 59 comparison of our data with data from other studies.
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24 60 • The cross-sectional nature of the study limits the ability to establish causal relationship
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26 61 between the observed factors and hypertension.
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28 62 • We could not measure all the potential risk factors for hypertension which could have
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30 63 enhanced the interpretation.
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34 64 **Keywords:** Hypertension, Bangladesh, Cross sectional study.
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65 INTRODUCTION

66 Each year an estimated 41 million people die from non-communicable diseases (NCDs)
67 accounting for about 70% of all deaths globally ¹. Hypertension is one of the most common
68 NCDs. According to the Global Burden of Disease (GBD) reports, between 1990 and 2010, there
69 has been a shift in disease burden from communicable diseases to NCDs ^{1 2}. This was most
70 notable in South Asia and sub-Saharan Africa regions, where a substantial proportion of the
71 world's population reside and where high blood pressure has had a particularly large effect on
72 disease burden ². Globally, high blood pressure was the 4th leading risk factor for GBD in 1990,
73 as quantified by disability adjusted life years (DALYs); it ranked as the leading risk factor in
74 2010 ². About one out of four adults around the world have hypertension and it is projected to
75 increase to 29.2% by 2025, which will be more than 1.5 billion people worldwide³⁻⁵.

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

81 The prevalence of hypertension is increasing, primarily in low- and middle-income
82 countries (LMICs) and remain steady or decreasing in high-income countries (HICs) ³. In South
83 Asia, the prevalence of hypertension is approximately 33% among people aged 18 years and
84 older with a secular trend documenting that the burden of hypertension is increasing over time ⁹.
85 South Asia region accounts for 23% (or an estimated 258 million) of global hypertension
86 burden⁹. An increase in hypertension prevalence in South Asia including Bangladesh could be
87 attributed largely to modifiable behavioral risk factors such as unhealthy diet, sedentary lifestyle,

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3 88 excess weight, tobacco consumption, alcohol abuse, and chronic stress including aging and
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5 89 urbanization¹⁰⁻¹².
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8 90 Bangladesh, like many other LMICs, is undergoing an epidemiologic transition and an increased
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10 91 understanding of the burden and risk factors of hypertension is necessary to combat the
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12 92 increasing burden¹³. A nationally representative survey conducted in 2011 (BDHS-2011)
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14 93 suggests that the prevalence of hypertension including undiagnosed and uncontrolled
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16 94 hypertension in Bangladeshi adults is high¹⁴⁻¹⁸. However, the available data is not adequate to
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18 95 provide regional or district level estimates. We have conducted this study among adults 35 years
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20 96 and older in a rural district of Bangladesh where we have been working for about two decades to
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22 97 develop and implement a scalable intervention for hypertension.
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28 99 **METHODS**

30 100 **Study design and setting**

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33 101 This was a population-based cross-sectional study conducted between August 2017 and January
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35 102 2018 in an established field research site in Zakiganj and Kanaighat sub-districts of Sylhet
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37 103 district of Bangladesh. The site is maintained by a research partnership of the Johns Hopkins
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39 104 University, Baltimore, Maryland, USA, the Bangladesh Ministry of Health and Family Welfare,
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41 105 and Bangladeshi non-governmental organizations. The study site is located in the north-east part
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43 106 of Bangladesh adjacent to the Indian states of Assam and Meghalaya, about 300 kilometers away
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45 107 from Dhaka, the capital city of Bangladesh. Every village and household in the study area are
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47 108 numbered. We conduct periodic census of the study area. We also maintain a surveillance
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49 109 through 2-monthly home visits to update vital events (births, deaths and movements) in women
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3 110 of child-bearing age and <5 children¹⁹⁻²¹ (19-21) but do not update adult population. We used
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5 111 2016 census database to select the study sample.
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9 113 **Sample Size**

11 114 Sample size was estimated to measure the prevalence of hypertension separately for adult males
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13 115 and females 35 years and older in the study population. Conservatively assuming a hypertension
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15 116 prevalence of 10% in both males and females, a $\pm 2\%$ precision, and a significance level of 5%,
16
17 117 the estimated sample size was 865 in each group. Assuming a 15% refusal or absence, we
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19 118 selected 1,020 individuals in each group. This sample size allows us to detect a 5% difference in
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21 119 the prevalence of hypertension between males and females.
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27 121 **Study Population and implementation**

29 122 Individuals, either a male or female aged 35 year and older were eligible to participate in the
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31 123 study. Pregnant women were excluded. We recruited the study participants from the database
32
33 124 using computer generated random numbers. They were visited in their homes by trained
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35 125 community health workers (CHWs) with a minimum of 10th grade education, who were already
36
37 126 collecting routine surveillance and other study specific data, including blood pressure
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39 127 measurement of pregnant women ^{22 23}. Given cultural sensitivities, two male CHWs were
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41 128 recruited to collect data from male participants. All CHWs received study specific training.
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45 129 Upon obtaining informed consent, CHWs administered an adapted version of the WHO's
46
47 130 expanded STEP instrument at the participant's home ^{24 25}. The instrument contained questions
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49 131 on NCD behavioral risk factors, including dietary habit, tobacco consumption, and physical
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51 132 activity. Data on other co-variates (e.g., household socio-economic status, education, occupation)
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53 133 were collected.
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3 134 After completing the household survey, CHWs measured blood pressure (BP) in mmHg
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5 135 using digital BP machine (OMRON 5 Series®, model: BP742N). The digital machines were
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7 136 calibrated fortnightly by a physician against a gold standard mercury sphygmomanometer.
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10 137 We measured both systolic and diastolic blood pressure three times at approximately 10-minute
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12 138 intervals between measurements¹⁶. All measurements were recorded in a data form and the
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14 139 average of the last two measurements were used for this analysis. During measurements, the
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16 140 study participant remained seated with legs uncrossed and back and arm supported. We used two
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18 141 different cuff sizes based on mid-upper arm circumference (MUAC) measurement. For
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20 142 participants with a MUAC of <22 cm, we used small cuff and for those with a MUAC of >22
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22 143 cm, we used a medium cuff. The cuff was placed above the left elbow at the level of chest. In
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24 144 addition, CHWs obtained measurements of weight (in kilograms), height (in centimeter), waist
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26 145 circumference (in centimeter), hip circumference (in centimeter) and mid upper arm
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28 146 circumference (MUAC, in centimeter) of the study participants using standardized methods.
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148 **Measurements**

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37 149 Blood pressure was classified as normal, pre-hypertension, or hypertension, based on criteria
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39 150 used in the World Health Organization-International Society of Hypertension (WHO-ISH)²⁶. A
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41 151 participant was considered to have normal blood pressure if systolic blood pressure (SBP) was
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43 152 <120 mmHg and the diastolic blood pressure (DBP) <80 mmHg and not taking antihypertensive
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45 153 drugs. An SBP of 120-139 mmHg or a DBP of 80-89 mmHg with no history of taking
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47 154 antihypertensive medication during survey was classified as prehypertension²⁷. A participant was
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49 155 considered having hypertension if the SBP was ≥ 140 mmHg or DBP was ≥ 90 mmHg or the
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51 156 blood pressure was below these cut-offs, but the study participant reported taking
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3 157 antihypertensive medication¹⁶. Controlled hypertension was defined as an SBP <140 mmHg and
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5 158 a DBP <90 mmHg and reported use of antihypertensive medication during survey¹⁶. A SBP of
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7 159 ≥ 140 mmHg or a DBP ≥ 90 mmHg in a study participant taking antihypertensive medication was
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9 160 considered as uncontrolled hypertension. An individual with SBP ≥ 140 mmHg or DBP ≥ 90
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11 161 mmHg with no history of taking antihypertensive medication was considered as newly identified
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15 162 or unaware of hypertension^{28 29}. The participants with high measured BP were referred to the
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17 163 hospital for further evaluation and care.

18
19 164 Participants' were categorized based on age into four groups (35-44, 45-54, 55-64, and
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21 165 ≥ 65 years old). We calculated body mass index (BMI) as the ratio of weight in kilograms to
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23 166 height in meters squared (weight in kg/height in m²) and categorized using the WHO-
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25 167 recommended cutoff points: underweight (<18.5 kg/m²), normal (18.5 – 24.9 kg/m²), and
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27 168 obese/overweight (≥ 25.0 kg/m²)³⁰. We categorized waist circumference into low risk (<90 cm
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29 169 for males and <80 cm for females) and high risk (≥ 90 cm for males and ≥ 80 cm for females). We
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31 170 created a household wealth score based on type of housing, source of drinking water, type of
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33 171 toilet, availability of electricity and household possessions as a measure of household economic
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35 172 status, using the Principal Component Analysis (PCA)^{31 32}. The wealth index is a composite
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37 173 measure of a household's cumulative wealth that places individual household on a continuous
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39 174 scale of relative wealth. We divided the households in to wealth tertiles .

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41 175 We used STEPS instrument to collect data on risk and protective factors³³. The data on
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43 176 fruits and vegetables intake were combined and categorized into <2 servings per day, 2-4
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45 177 servings per day and ≥ 5 servings per day. Participants were defined as a current smoker if they
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47 178 reported smoking cigarettes, cigars, or pipes during the survey. Similarly, participants were
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49 179 defined as a current smokeless tobacco user if reported using smokeless tobacco products such as
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3 180 snuff, chewing tobacco leaf, *goul*, *noshi* or *zarda* at the time of the survey. We collected data on
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5 181 physical activity (PA) across all domains including work, transportation (walking/biking) and
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7 182 leisure- time/recreational activity. Data on time spent on PA were converted into minutes per
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9 183 week and then we calculated metabolic equivalent task (MET)-minutes per week for all activities
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11 184 combined³⁴. According to standard classification, a MET-minute of <600 per week is classified
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13 185 as low PA, 600-3000 MET-minutes is considered as moderate PA and >3000 MET-minutes is
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15 186 considered as high PA. In our population, there was none with high PA. Based on distribution of
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17 187 MET-minutes, we have categorized our population into very low PA (<300 MET-min/week),
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19 188 low PA (300 to <600 MET-min/week) and moderate PA (>600 MET-min/week).
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26 190 **Data analysis**

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28 191 We presented percent distribution of selected sociodemographic and other factors including
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30 192 median and interquartile range for continuous variables for the total sample as well as separately
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32 193 for males and females. We calculated the prevalence and 95% confidence intervals (CI) of
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34 194 hypertension, pre-hypertension, controlled, uncontrolled and unaware or newly identified
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36 195 hypertension using WHO-ISH guidelines²⁶. Bivariate and multivariable logistic regression were
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38 196 used to identify factors significantly associated with hypertension separately for males and
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40 197 females. First, we conducted bivariate logistic regression analysis. Variables with a p-value of
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42 198 <0.05 in the bivariate analyses were included in the multivariable logistic regression model. In
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44 199 addition, we have added a few variables (smoking, consumption of fruits and vegetables and
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46 200 physical activity) as a priori even if those variables were not statistically associated in bivariate
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48 201 analysis because these variables have been shown to be associated with hypertension and there is
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50 202 biological basis for it. Data was analyzed using Stata version 15 (StataCorp 2015).
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203 We obtained approval from the National Research Ethics Committee of the Bangladesh
 204 Medical Research Council (BMRC) and the Institutional Review Board (IRB) of the Johns
 205 Hopkins Bloomberg School of Public Health, USA to conduct the research.

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

208 209 RESULTS

210 We approached 1,020 males and 1,019 females aged 35 years or older (total of 2,039) for study
 211 participation. Among the 1,020 males, 29 (2.8%) refused participation, 49 (4.8%) were absent,
 212 48 (4.7%) migrated out, and 28 (2.7%) died. Among the 1,019 females, 7 (0.7%) refused, 7
 213 (0.7%) were absent, 28 (2.7%) migrated out, 14 (1.4%) died, and 14 (1.4%) were excluded
 214 because they were pregnant. Of the 1,810 participants who completed the survey, 864 were male
 215 and 946 were female. Distributions of sociodemographic and lifestyle characteristics of male,
 216 female and all participants are presented in Table 1.

217
218 **Table 1: Socio-demographic and lifestyle characteristics among adult males and females in**
 219 **Sylhet district of Bangladesh**

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

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

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

223 The median ages of male and female participants were 50 (IQR 42, 60) years and 47
 224 (IQR 40, 57) years, respectively. The median BMI of males and females were 20.1 (IQR 18.2,
 225 22.5) and 20.5 (IQR 18.0, 23.3) kg/m², respectively. Among females, 16.9% were
 226 overweight/obese and 42.5% had high waist circumference (≥80 cm). Majority of the males
 227 (63.2%) reported smoking currently compared to 3.8% of the females who did so. About 14.5%
 228 males and 10.5% females reported intake of ≥5 servings of fruits and vegetables per day.
 229 Majority of the males (57.8%) and most females (93.7%) reported very low PA. (Table 1).

230 The prevalence and 95% confidence interval of hypertension was 18.8% (16.3-21.5) in
 231 males and 18.7% (16.3-21.3) in females (Table 2). Among those with hypertension, the
 232 prevalence of controlled, uncontrolled and unaware/newly identified hypertension was 23.5%,
 233 25.9% and 50.6%, respectively among males and 38.4%, 22.6% and 39.0%, respectively among
 234 females (Table 2 and figure 1). Another 22.7% of the males and 17.8% of the females were pre-
 235 hypertensive.

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

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

254 Notes: ¹SBP <120 mmHg and DBP <80 mmHg and not taking antihypertensive medication; ²SBP 120-
 255 139 mmHg or DBP 80-89 mmHg and not taking antihypertensive medication; ³SBP ≥140 mmHg or DBP
 256 ≥ 90 mmHg or taking antihypertensive medication; ⁴SBP <140 mmHg and DBP < 90 mmHg but taking
 257 antihypertensive medication; ⁵SBP ≥140 mmHg or DBP ≥ 90 mmHg and taking antihypertensive
 258 medication; ⁶SBP ≥140 mmHg or DBP ≥ 90 mmHg and not taking antihypertensive medication.

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

267 males, compared to those with very low PA, those with low and moderate PA had lower
 268 prevalence of hypertension (Table 3).

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

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

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

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3 273 In the adjusted logistic regression model, we included waist circumference but not BMI
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5 274 because they were highly correlated ($r = .68$). In the adjusted analysis, among males, age older
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7 275 than 45 years and waist circumference ≥ 90 cm was positively and reported low and moderate PA
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9 276 were inversely related to risk of hypertension (Table 3). Among females, older age, higher
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11 277 socioeconomic status and waist circumference ≥ 80 cm was positively related with risk of
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13 278 hypertension (Table 3). The odds of hypertension were increasing as the age was increasing both
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15 279 in males (45-55 y: adjusted odds ratio [aOR] 1.3, 95% CI: 0.8-2.4; 55-64 y: aOR 3.0, 95% CI
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17 280 1.7-5.4, 65+ y: aOR 3.5, 95% CI 2.0-6.3) and in females (45-55 y: aOR 2.3, 95% CI 1.5-3.8, 55-
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19 281 64 y: aOR 3.1, 95% CI 1.7-5.4, 65+ y: aOR 5.7, 95% CI 3.4-9.5). The odds of hypertension were
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21 282 four-folds higher among males (aOR 4.0, 95% CI 2.5-6.4) and three-folds higher among females
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23 283 (aOR 2.9, 95% CI 2.1-4.1) with high waist circumference (≥ 90 cm in males and ≥ 80 cm in
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25 284 females). In a subsequent adjusted model, we replaced waist circumference by BMI;
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27 285 overweight/obese was significantly associated with greater odds of hypertension in both males
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29 286 (aOR 3.1, 95% CI 1.8-5.3) and females (aOR 1.9, 95% CI: 1.2-2.9) (data not shown).
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38 288 **DISCUSSION**

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40 289 In this population-based cross-sectional study in rural Bangladesh, the prevalence of
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42 290 hypertension was high among both males (18.8%) and females (18.7%). The prevalence of pre-
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44 291 hypertension was also high at 22.7% among males and 17.8% among females. Among those who
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46 292 had hypertension, more than half of the males and about a third of the females were not aware of
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48 293 it. Additionally, about a quarter of the hypertensive males and females had uncontrolled
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50 294 hypertension. Compared to males, a higher proportion of females had controlled hypertension.
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3 295 The data on prevalence of and risk factors for hypertension in Bangladesh is limited. The
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5 296 Bangladesh Demographic and Health Survey 2011 (BDHS-2011) measured blood pressure in a
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8 297 nationally representative sample of adult males and females¹⁶. The BDHS estimates of
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10 298 hypertension prevalence for Sylhet division were similar to our finding among males but was
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12 299 higher (25.2%) among females. However, the BDHS Sylhet prevalence rate for females was
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14 300 based on 232 women with a wide confidence interval (19.6-31.1). BDHS documented a
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16 301 substantial urban versus rural and regional variations. The urban sample had a much higher
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18 302 prevalence than the rural sample (40.2% vs 29.4%). Among eight divisions (regions) of
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20 303 Bangladesh, Sylhet division where the current study was conducted, had the lowest prevalence
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22 304 (25.2%)¹⁶. Our findings of prevalence of hypertension is similar in females (18.4% vs 18.7%)
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24 305 but higher in males (13.5% vs 18.8%) than in a study conducted among adults 25 years and older
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26 306 in 2005 in three rural areas of Bangladesh³⁵.

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31 307 Our findings of positive associations between hypertension and potential risk factors such
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33 308 as age, BMI, and waist circumference are consistent with several studies from Bangladesh and
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35 309 elsewhere^{17 18 36}. A dose response relationship was observed between the risk of hypertension
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37 310 and age, the risk increased with the increase of age; highest risk was observed in the oldest age
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39 311 groups among both males and females^{18 37}.

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42 312 High BMI is an established risk factor for hypertension¹⁵; several studies found that
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44 313 overweight/obesity had the strongest association with hypertension^{35 38 39}. Body weight is the
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46 314 balance between consumption and expenditure of energy. One would expect higher calorie
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48 315 consumption among higher SES group. Adult males and females with a higher waist
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50 316 circumference had four- and three-fold higher risks of hypertension, respectively. Both BMI and
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52 317 waist circumference are established risk factors for hypertension. In our study, we analyzed
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3 318 them separately but presented waist circumference data instead of BMI because several studies
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5 319 suggested that abdominal fat deposition is generally a stronger predictor of hypertension than
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7 320 BMI-based association^{40 41}. Moreover, we chose waist circumference in our model instead of
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9 321 BMI because it can be easily measured, and programs can use it for screening provided training
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11 322 is adequate.

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14 323 Compared to those who belonged to the poorest wealth group, we observed about a two-
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16 324 fold higher risk of hypertension among females but not among males who belonged to higher
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18 325 wealth groups. The association of socio-economic status with hypertension is not consistent
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20 326 across studies; some studies observed higher rate of hypertension among higher socioeconomic
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22 327 group and yet, other studies observed higher rate among the poor^{35 42 43}. A recent review reported
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24 328 an overall increased risk of hypertension among the lowest SES, particularly in high-income
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26 329 countries⁴³.

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29 330 Association between PA and risk of hypertension are well documented. Interventional
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31 331 studies showed beneficial effects of PA on blood pressure reduction^{44 45}. Recreational PA is
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33 332 uncommon in our population (<1%). We observed a lower risk among males who reported PA
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35 333 for ≥ 300 MET minutes per week. Compared to those with very low PA, the odds of having
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37 334 hypertension was 40.0% and 70.0% less among males who had reported low and moderate PA
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39 335 respectively.

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42 336 We did not see a protective effect of fruit or vegetable consumptions on hypertension in
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44 337 our population. In this poor agrarian community most people consume vegetables every day, the
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46 338 quantity might be low. Fruit consumption is low among rural Bangladeshi people. Seasonal
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48 339 fruits are grown in abundance but are not popular because people do not consider them as good
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50 340 fruit⁴⁶. Imported fruits are costly and remain unaffordable to many people leading to a very low
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3 341 consumption of fruit ⁴⁶. The benefit of fruits and vegetable consumption is primarily through
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5 342 increased intake of potassium ^{47 48}. All vegetables may not contain high level of potassium and
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8 343 washing, and cooking may reduce potassium level ⁴⁹. In this study, we did not see a higher risk
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10 344 among smokers. Not seeing a benefit of fruit and vegetable consumptions or not seeing an
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12 345 increased risk among smokers could be due to reverse causation i.e., those with hypertension
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14 346 might have modified their behavior but that is unlikely because about half of those hypertensive
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17 347 were newly diagnosed.

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19 348 The study has several limitations. The cross-sectional nature of the study limits the ability
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21 349 to establish causal relationship between the observed risk factors and hypertension. Also, the
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23 350 study was conducted in one region of Bangladesh and may not be generalizable for the entire
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25 351 country. The sample size is small, which limited risk factor analysis. We did not collect data on a
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27 352 number of important factors that may be associated with hypertension including family history,
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29 353 life style and salt intake. We defined hypertension by measuring blood pressure levels at the
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31 354 field level, not in a clinic setting. However, our workers were adequately trained and had years
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33 355 of experience measuring blood pressure in the field setting. We calibrated the blood pressure
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35 356 machines fortnightly against mercury sphygmomanometer. This survey used standard and pre-
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37 357 tested STEPs questionnaire to collect data from study participants which is used widely allowing
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40 358 comparison of our data with data from other studies.

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44 359 Our finding of high rates of hypertension in this rural area is important because the risk of
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46 360 CVDs is about 16 folds higher among those with hypertension compared to those with a SBP of
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48 361 <115 and DBP of <75 ⁵⁰. However, the risk of CVDs is higher for all individuals with a SBP
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50 362 >115 or DBP >75 ⁵⁰⁻⁵². For every 10 mm increase in BP, the risk almost doubles. Although the
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52 363 risk is lower in the so-called normal BP groups compared to those with hypertension, since there
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3 364 are many more individuals in these BP categories, the burden of CVD related to hypertension
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5 365 among them is substantial. Therefore, efforts need to be made to identify and control
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8 366 hypertension and adopt strategies to reduce blood pressure of the entire population and prevent
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10 367 rise of BP with age.

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12 368 Our results show a high prevalence of hypertension and pre-hypertension in the surveyed
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14 369 population. In addition, high prevalence of newly diagnosed and uncontrolled hypertension
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16 370 despite the availability of low cost and safe drugs for hypertension is a major public health
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18 371 concern. Apart from age, the most important risk factor of hypertension is behavioral and
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20 372 potentially modifiable. For example, inappropriate diet and inadequate physical inactivity lead to
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22 373 overweight/obesity, raises blood pressure and increases unfavorable blood lipids. These factors
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24 374 together with tobacco use, explain at least 75% of cardiovascular disease. Addressing behavioral
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26 375 risk factors, particularly unhealthy diet and physical inactivity can prevent hypertension. Salt
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28 376 reduction initiatives can make a major contribution to prevention and control of high blood
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30 377 pressure. However, vertical programs focusing on hypertension control alone are not cost
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32 378 effective⁵³. Integrated context specific program including behavior change and identification and
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34 379 management of hypertension needs to be designed and implemented at scale through a primary
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36 380 health care approach. That will be an affordable and sustainable approach for countries to tackle
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38 381 the increasing burden of hypertension⁵³.

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391 **AUTHOR CONTRIBUTIONS**

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

399 **COMPETING INTERESTS**

400 All authors declare that they have no conflict of interest

401 **DATA SHARING STATEMENT:**

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

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407 not-for-profit sectors.

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2
3 409 **Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist**
4 410 **circumference, Sylhet, Bangladesh**
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For peer review only

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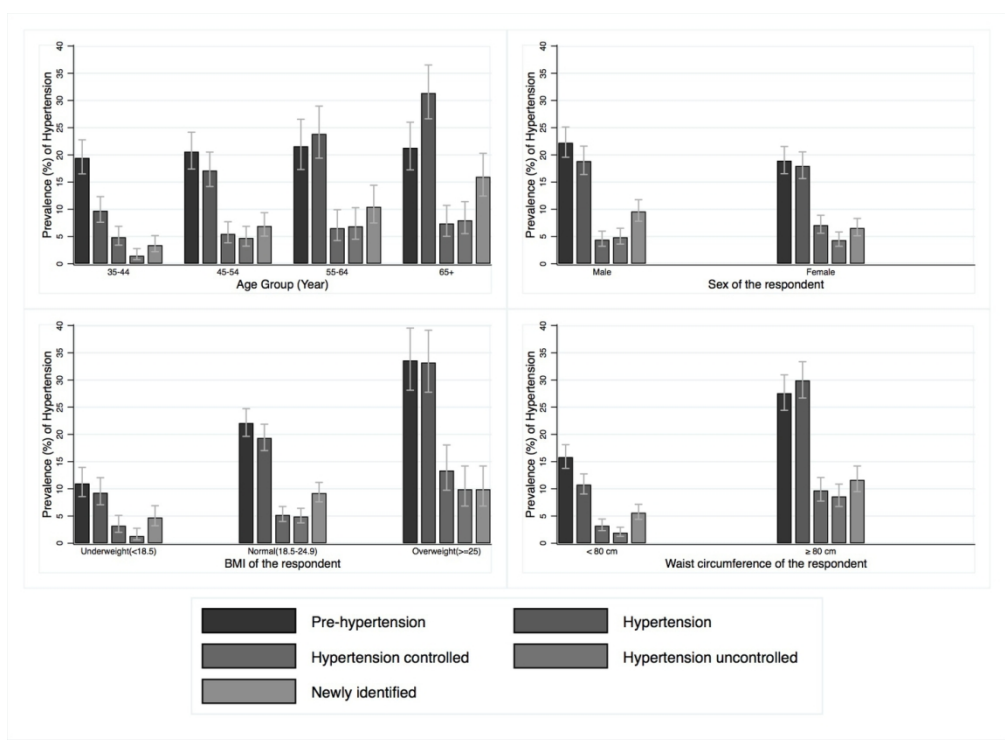


Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist circumference, Sylhet, Bangladesh

123x90mm (300 x 300 DPI)

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

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

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

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3 *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.
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6 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE
7 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
8 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.
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