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Gender-specific prevalence and associated factors of hypertension among elderly Bangladeshi people: findings from a nationally representative survey

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Abstract

Objective: We aimed to estimate the gender-specific prevalence and associated factors of hypertension among elderly people in Bangladesh using data from a nationally representative survey.

Design and method: We analyzed data from the food security and nutrition surveillance round 2018-19. The multistage cluster sampling method was used to select the study population. Hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg and/or having a history of hypertension. We carried out the descriptive analysis, bivariate and multivariable logistic regression to report the weighted prevalence of hypertension as well as crude and adjusted odds ratios with 95% confidence interval. A p-value <0.05 was considered statistically significant.

Setting: The study was conducted in 82 clusters (57 rural, 15 non-slum urban, and 10 slums) in all 8 administrative divisions of Bangladesh.

Participants: A total of 2,482 males and 2,335 females aged ≥60 years were included in the analysis.

Results: The weighted prevalence of hypertension was 42% and 56% among males and females, respectively. The prevalence was higher among females across all sociodemographic, behavioral, and

biological strata. Factors associated with higher odds of hypertension in both sexes were age 70+ years [AOR with 95%CI: 1.32 (1.09,1.60) for males and 1.40 (1.15,1.71) for females]; insufficient physical activity [AOR with 95%CI: 1.50 (1.25,1.81) and 1.38 (1.15,1.67)]; central obesity [AOR with 95%CI: 2.76 (2.22,3.43) and 2.20 (1.82,2.67)]; and self-reported diabetes [AOR with 95%CI: 1.36 (1.02,1.82) and 1.82 (1.35,2.45)]. Additionally, more than 10 years of education increased odds of hypertension [AOR with 95%CI: 1.83 (1.38,2.44)] among males.

Conclusion: In Bangladesh, both elderly males and females have a high prevalence of hypertension, with disproportionately greater prevalence among females. The Ministry of Health of Bangladesh should consider this while designing and implementing health programs for elderly people.

Keywords: Hypertension, elderly people, prevalence, Bangladesh

Strengths and limitations of this study

- Information on the prevalence, sex-difference, and associated factors of hypertension among the elderly Bangladeshi population are scarce.
- The nationally representative design allowed the objective assessment of the prevalence, sex-difference, and factors of hypertension among the elderly Bangladeshi population.
- Blood pressure was measured on a single day rather than longitudinal measurements to confirm the diagnosis of hypertension.
- The associations might not be causal due to lack of temporality, as the study was a cross-sectional one.
- Some strong confounders such as salt consumption, genetic factors could not be addressed.

Introduction

The proportion of the aging population around the world is rapidly increasing, and the pace is faster than ever. The global population aged ≥60 years reached 962 million in 2017, more than double compared to 1980 and is projected to double again by 2050 when it reaches 2.1 billion [1]. In another estimate, globally, the population aged ≥60 years will be 22% by the year 2050, and 80% of which will live in low and middle-income countries [2]. In 2017, 8.8% of the South Asian population was aged ≥60 years, which is projected to be 18.9% by 2050 [1]. Despite its arbitrary nature, persons aged ≥65 years are considered as elderly in most of the developed countries [3]. However, in Bangladesh, persons aged

≥60 years are considered as elderly people considering the shorter longevity [4]. Bangladesh witnessed a five-fold increase in the elderly population between 1974 and 2001 [5]. According to the Bangladesh Bureau of Statistics, about 12.5 million (7.5%) of Bangladeshi people were elderly in 2019, which is expected to be 40 million (20%) by the year 2050 [6].

Hypertension or raised blood pressure is a condition when the pressure of blood flow on the vessel walls become higher than normal [7]. People often are not aware of whether they are hypertensive or not, and hence it is often called the "silent killer" [8]. Globally, hypertension is one of the major causes of deaths and disabilities. According to the World Health Organization Global Health Observatory (GHO) 2016 data, 7.5 million annual deaths were estimated to be caused by high blood pressure, which was about 12.8% of total deaths worldwide. Hypertension is also accounted for 57 million disability-adjusted life years (DALYs), which amounts to 3.7% of total DALYs [9]. Globally, hypertension is responsible for 45% of deaths from cardiac causes, and 51% of the deaths from stroke [10]. As a risk factor, hypertension causes nearly 30% of all cardiovascular disease [11].

The prevalence of hypertension substantially increases with age. Evidence from the Framingham heart study, the longest-standing study on cardiovascular disease epidemiology, showed that more than 90% of the people who remain normotensive at the age of 65 years would develop hypertension at their remaining life-span, may be due to age-related vascular changes [12]. Bangladesh Demographic and Health Survey 2011 (BDHS 2011) reported that 30% of the males and 52% of the females aged ≥65 years were hypertensive, along with 25% of both sexes of the same age group were prehypertensive [13]. Another study reported that the prevalence of hypertension among Bangladeshi adults and elderly (≥60 years) population was 25% and 40%, respectively [14]. The same study reported that an estimated 23% of the elderly people in rural Bangladesh had undiagnosed hypertension, and among those who were diagnosed and were receiving treatment, 68% had uncontrolled hypertension.

Despite these facts, hypertension among elderly people in this region could not gain enough attention. One of the reasons can be limited information due to poor or no screening and control measures for hypertension among the elderly population. To the best of our knowledge, there is no study reporting national prevalence and associated risk factors of hypertension among the elderly Bangladeshi population of 60 years and above. Even some studies have excluded older adults who are at higher risk of NCDs. Accordingly, the objective of our study is to report the prevalence and factors associated with hypertension among elderly males and females of Bangladesh.

Materials and Methods

Study design and site

We conducted a cross-sectional survey among six population groups (children <5 years, adolescent boys, adolescent girls, adult females, adult males, and elderly people). Our objective was to generate nationally and divisionally representative estimates of different nutrition and health-related variables, including major noncommunicable diseases in elderly males and females. The data collection period was from October 2018 through October 2019. In this nationally representative study, we enrolled participants from all eight administrative divisions (Barisal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, and Sylhet) and covered rural, non-slum urban and slum areas. We enrolled in study subjects from 82 randomly selected clusters (57 rural, 15 non-slums urban, and 10 slums).

Sample size and sampling techniques

We determined the sample size to generate nationally, and divisionally representative prevalence for the selected indicators with prevalence ranged from 4% to 98% using a multistage cluster sampling. We considered the type I error, $\alpha = 0.05$; allowable margin of error, $d = 0.05$ (or d = prevalence/2 if prevalence ≤ 0.1); design effect, DEF = 1.61 and calculated a sample size of 62 elderly individuals from each cluster. Accordingly, the sample size for the elderly population was 5,580 from 90 clusters in the country. Finally, we could complete collecting data from 82 clusters and obtained a sample size of 4,894 elderly people.

Separate sampling designs were applied to select the study sites in rural, urban, and slum areas. For the rural area, two districts were first selected from each division in the first stage of four-stage sampling. From each district, two sub-districts (upazilla) were randomly selected. In the third stage, two unions were randomly chosen from each of the selected sub-districts. The villages/mouzas/geographically demarcated segments with 250-400 households were then identified and mapped. Finally, we randomly selected two of the listed village/mouza/segments from each union as study clusters.

In the urban areas, we used the population proportion of Bangladesh Bureau of Statistics (BBS) 2011 census [15]. We randomly selected 16 wards (1-2 wards/division). We then identified the Mahalla (similar to the villages) with more than 250 households, and the mahallas with >500 households were further sub-divided into smaller geographically demarcated segments of ~250 households. We randomly picked one segment from the listed segments from the selected wards, and that was our study cluster.

In the slum areas, the Census of Slum Areas and Floating Population 2014 was used for the selection of study sites [16]. Slums having ≥ 300 households were identified, and those with >500 households were

further divided into smaller segments. Two segments from the Dhaka and Chattogram divisions and one from each of the other six divisions were randomly selected as study clusters.

For each cluster, data collectors first listed all households with individuals aged ≥60 years. A statistician then selected 80 households from the list using Simple Random Sampling to enroll 62 elderly people from a cluster. If any household had more than one person aged ≥60 years, we randomly selected one.

Figure 1: Study flow chart of participants selection (aged ≥60 years)

Data Collection

We collected data using a structured questionnaire, developed initially in English, and then translated into the local language. Data were collected using face to face interviews and physical measurements and were directly entered in tablet computers (Samsung Galaxy Tab A7) using a customized SurveyCTO application [17]. At the end of everyday data collection, data collectors uploaded all the collected data to the server. We measured the height (using locally made portable stadiometer), weight (using TANITA UM-070 weighing scale), waist circumference (using measuring tape), and blood pressure (using Omron HEM 7120) of the elderly people.

Anthropometric measurements were taken based on WHO guidelines, as specified in the Food and Nutrition Technical Assistance (FANTA) anthropometry manual [18]. The weight was measured to the nearest 0.1 kg with light cloths, and height was measured to the nearest 0.1 cm in the standing position with no shoes. Waist circumference was measured to the nearest 0.1 cm at the end of a normal expiration, at the midpoint between the lower part of the last rib and the top of the hipbone, with the arms relaxed at the sides. Usually, we took two measurements of weight, height, and waist circumference, and if the gap between the two first measurements were >0.1 kg for weight and >0.5 cm for height and waist circumference, we took the third measurement. Before measuring blood pressure, the data collector ensured that the participant was in a resting condition for at least 15 minutes. There was a three minutes interval between two subsequent measurements. If there was a gap of ≥10 mmHg between the first two measurements of systolic and/or diastolic blood pressure, a third measurement was taken.

Operational definitions

The outcome variable in our analysis was the hypertension status of elderly males and females.

Hypertension was defined as systolic blood pressure ≥140 mmHg, or diastolic blood pressure ≥90 mmHg or if the participants were told as hypertensive by any trained health care provider (self-reported) [19]. The variable was made dichotomous either as hypertensive (measured or self-reported) or as non-hypertensive to facilitate logistic regression.

We made a list of potential factors associated with hypertension among elderly people based on literature review and types of data collected by the survey. The socioeconomic factors were age (60-69 years vs. 70+ years), place of residence (rural, non-slum urban, and slum), education (no formal education, up to primary level, up to 10 completed years and >10 completed years), wealth status, marital status (currently married vs. never married, divorced, widowed or separated), and religion (Muslim vs. others).

The behavioral factors were physical activity, fruits and vegetable consumption (≥5 servings/day vs. <5 servings), current smoking status (no vs. yes), and smokeless tobacco consumption status (no vs. yes). An elderly person was considered doing adequate physical active (during work, transport, and recreational activities), if he or she reported at least 150 minutes of moderate-intensity physical activity per week or 75 minutes of heavy physical activity per week or equivalent [20].

Body mass index, waist circumference, and self-reported diabetes were the anthropometric and clinical factors. We used the Asian cutoff to categorize Body Mass Index (BMI) into underweight (<18.5 kg/m2), normal (≥18.5 to <23.0 kg/m2), overweight (≥23.0 to <27.5 kg/m2, and obese (≥27.5 kg/m2) [21]. Central obesity was defined as the waist circumference of ≥90 cm in males and ≥80 cm in females [22]. For this analysis, we considered the average of the two closest measurements for blood pressure and all anthropometric variables. Self-reported diabetes was documented if any participant reported that a trained health care provider ever told him or her that he or she had diabetes.

Quality Assurance and Control

Data collectors an field supervisors received extensive training on interviews, anthropometric measurements, and maintenance of data collection instruments and had gone through a rigourus standardization procedure. We field-tested the questionnaire, modified it and refreshed the data collectors based on the findings of field testing. To ensure data quality, the field supervisors directly observed 5% of the interviews and re-interviewed another 5% of the randomly selected participants within 48 hours of the initial visit. Interim analyses were performed to check the data quality. All the measuring tools were calibrated routinely.

Statistical Analysis

We performed all the data analysis using Stata 15.1 (Stata Corp, College Station, TX, USA) [23]. All the background characteristics are reported as categorical variables. We performed principal component analysis (PCA) to calculate wealth quintiles of the households of the participants. We estimated the weighted prevalence of hypertension for both elderly males and females. As the males and females differed by the distribution of risk factors and the prevalence of hypertension, we conducted separate bivariate and multivariable logistic regression, respectively, to identify the factors associated with hypertension. The variables with a p-value of ≤0.2 in the crude analysis were included in the multivariable logistic regression model a[24]. Variance inflation factors (VIFs) were also checked to assess multi-collinearity among variables. We included both BMI and waist circumference separately in our initial analysis as both are important predictors of hypertension. But finally, we used the waist circumference in the regression model due to its high correlation with BMI (r = 0.87) as well as its program implications as waist circumference can be easily measured and interpreted for screening in a low resource setting. Crude and adjusted odds ratios were estimated at 95% confidence intervals, and the determinants with the p-value <0.05 were considered statistically significant.

Ethical considerations

The FSNSP 2018-19 obtained the ethical approval from the Institutional Review Board (IRB) of the BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh (IRB Reference number: 2018-020-IR). Written informed consent was taken from the respondents before data collection and measurements.

Patient and public involvement

No patients or public were directly involved in conceptualization, design, data collection, or dissemination of this study. However, the data collection supervisors explained the study procedure and purpose to the local leaders to receive community consent.

Results

Table 1 describes the characteristics of the study participants. Of the participants, 2,482 (51.5%) were male and 2,335(48.5%) were female. The median and the interquartile range of age of the males and females were 65.7 (62.6-71.4) years and 66.0 (62.3-72.9) years. About 72% of the participants were from the rural area, whereas 17% from non-slum urban and 11% from the slums. About 63% of the participants had no formal education, and this proportion is higher among females (77.1%) than their

male counterparts (48.9%). About 14.8% of elderly males and only 1.8% of elderly females completed education above the secondary level. Among the participants, about 92% of males and 25% of females were currently married. More than 42% of males and 45% of females reported insufficient physical activity. As per the data, daily fruits and vegetable consumption of 9 out of 10 elderlies were <5 servings. About 37% of males and 3% of females reported themselves as current smokers, whereas about 41% of elderly males and 58% of elderly females reported themselves as a current user of smokeless tobacco. A higher proportion (34.4%) of females were overweight or obese than the males (28.0%), whereas the prevalence of underweight was the same. Central obesity was identified among 23% of males and 41% of females. About 11% of elderly males and 13% of elderly females reported having diabetes.

Table 1: Background characteristics of the study population by sex

Figure 2 demonstrates the distribution of a few selected behavioral and clinical characteristics across the places of residence and sexes. In our study, the prevalence of these risk factors is higher among elderly females compared to their male counterparts except for insufficient physical activity in urban areas. Almost 80% of males and 78% of females of the non-slum urban area reported performing an insufficient physical activity, which is around 40% in both rural and slum areas. Overall, 91% of the elderly were consuming inadequate fruits and vegetables, which was 94% in females and 87% in males. However, above 98% of slum women failed to consume the recommended servings of fruits and vegetables. Overweight/obesity was also highest in urban females, which was about 38% compared to 22% in urban males. Similarly, 60% of urban females were identified with central obesity.

Figure 2: Selected behavioral and clinical characteristics by area of residence and gender

Table 2 shows the prevalence of hypertension according to the characteristics of the participants. The overall prevalence of hypertension was 49%, which was 42% in males and 56% in females. Urban elderly females had the highest prevalence of hypertension (63%), whereas the male slum dwellers had the lowest prevalence (30%). With respect to wealth quintiles, the wealthiest of the population had the highest prevalence of hypertension in both sexes (51% in males and 62% in females). The prevalence of hypertension increased with age, education, body mass index, and waist circumference in both sexes. Married elderly males had a lower prevalence of hypertension (41% vs. 58%). Moreover,

the prevalence of hypertension was lower among those who reported sufficient physical activity, and adequate consumption of fruits and vegetables. Unexpectedly, the prevalence of hypertension was found lower among current smokers (35% vs. 52%). However, the prevalence of hypertension did not differ much between current users and non-users of smokeless tobacco in this survey.

Table 2: Prevalence of hypertension according to background characteristics among elderly males and females (weighted) with 95% Confidence Interval

We reported the results of bivariate and multivariable logistic regressions in Table 3. In bivariate analysis, we found that all the selected variables were significantly associated with hypertension in males, whereas in females, we found that age, place of residence, education, wealth index, marital status, physical activity, smokeless tobacco use, BMI, waist circumference and diabetes were significantly associated with hypertension. However, in multivariate analysis, we found that age, physical activity, waist circumference, and self-reported diabetes were significantly associated with hypertension for both males and females, whereas the place of residence, education, and smoking were associated with hypertension only in case of the elderly males.

Table 3: Factors associated with hypertension among elderly Bangladeshi people stratified by sex

For elderly males, age, education, and waist circumference demonstrated an association with hypertension. Elderly males had higher odds of hypertension for being aged ≥70 years (AOR: 1.32; 95% CI: 1.09, 1.60; p-value: 0.005); having education up to SSC (AOR: 1.25; 95% CI: 1.00, 1.56; p-value: 0.049); having education above SSC (AOR: 1.83; 95% CI: 1.38, 2.44; p-value <0.001); having waist circumference ≥90cm (AOR: 2.76; 95% CI: 2.22, 3.43; P-value: <0.001). On the other hand, living in the slums (AOR: 0.71; 95% CI: 0.52, 0.96; p-value: 0.025); and being current smoker (AOR: 0.74; 95% CI: 0.61, 0.89; p-value: 0.002) were found as negatively associated with having hypertension among elderly males. Insufficient physical activity (AOR: 1.50; 95% CI: 1.25, 1.81; p-value <0.001) and self-reported diabetes (AOR: 1.36; 95% CI: 1.02, 1.82; p-value: 0.037) were found as two risk factors of hypertension among elderly males when adjusted with other covariates. However, wealth index, marital status, religion, consumption of fruits and vegetables were not found associated with having hypertension among males while adjusted with the confounders.

For elderly females, age and waist circumference demonstrated an association. Elderly females had higher odds of having hypertension for being aged ≥70 years (AOR: 1.40; 95% CI: 1.15, 1.71; p-value: 0.001); and waist circumference ≥80cm (AOR: 2.20; 95% CI: 1.82, 2.67; P-value: <0.001).

Insufficient physical activity (AOR: 1.38; 95% CI: 1.15, 1.67; p-value: 0.001) and self-reported diabetes (AOR: 1.82; 95% CI: 1.35, 2.45; p-value <0.001) were also identified as the risk factors of hypertension among elderly females when adjusted with other covariates. However, no other variables, including education, wealth index, and consumption of fruits and vegetables, were found associated with having hypertension among females in multivariable logistic regression.

Discussion

In our study, the overall prevalence of hypertension among the elderly people of Bangladesh was 49%, which is similar to the south Asian prevalence of hypertension among elderlies aged ≥65 years (53%) but lower than the average prevalence in the low and middle-income countries (66%) reported in a recent systematic review and meta-analysis [25]. Our reported prevalence is higher than the prevalence estimated in Bangladesh demographic and health survey 2011, which was 35% and 40% for the age groups 60-69 and 70+ years, respectively [26]. The increase in the prevalence of hypertension may be due to recent advancements in the economy and infrastructure of the country, along with rapid urbanization, sedentary lifestyles, and stress [27-29]. Hypertension is considered the most important modifiable risk factor of cardiovascular diseases worldwide [30]. It has been shown that hypertension is responsible for nearly 30% of all cardiovascular diseases, and a person with hypertension has nearly three times the likelihood of having cardiovascular incidents compared to non-hypertensive individuals [11]. As a major contributor to cardiovascular diseases, hypertension causes a major proportion of ischemic heart diseases, heart failure, renal failure, as well as cerebrovascular diseases such as stroke [31]. As almost half of the population in the elderly age group in Bangladesh is hypertensive, we can indisputably assert that Bangladesh must take immediate steps to address this problem. Policymakers need to pay special attention while designing the screening and intervention program considering the health and wellbeing of the elderly people.

After segregating by sex, the prevalence of hypertension was 42% and 56% for males, and females, respectively. This higher prevalence among females is supported by several studies in Bangladesh and elsewhere [32]. It may be due to a lack of ovarian hormones during the postmenopausal period. Studies suggested that ovarian hormones, especially estrogen, may have the potentials to keep the blood pressure lower in premenopausal women, and lack of it may be responsible for elevated blood pressure in postmenopausal women [33]. Moreover, our findings indicate that women, at their advanced age, become socially more vulnerable to hypertension. For example, three out of four elderly women did not have a spouse, and it may affect their health care seeking and treatment. The government should pay additional attention to design customized screening and awareness programs for elderly people with special attention to the vulnerability of women.

Our study corroborated the fact that the risk of developing hypertension increases with age in both sexes. Studies conducted in Bangladesh [13], India [34], Pakistan [35], Nepal [36], Indonesia [37], and China [38], have shown that the older age group had a higher prevalence of hypertension. The biological effect of the increased arterial resistance due to age-related changes in the arterial wall, i.e., thickening of the arterial wall in old ages, may contribute to high-risk of hypertension in older ages [39]. Bangladesh is in the midst of a huge demographic transition, and with the decreasing trend of birth and death rate, the proportion of the elderly population is growing which will eventually add more hypertensive patients and create more pressure on the already over-burdened health system of the country. In this study, insufficient physical activity was found significantly associated with hypertension in both sexes. Elderlies, who reported less than 150 minutes of moderate-intensity or equivalent physical activity per week, had around 1.5 times more odds of having hypertension. This finding is supported by numerous studies [13 36 40]. Besides, physical inactivity was also found associated directly with stroke and ischemic heart diseases [41]. Elderly males and females with higher waist circumference had three times and two times more odds of having hypertension, respectively. Several studies have reported that waist circumference, as it represents central obesity, is a better predictor of hypertension compared to BMI [42 43].

In this study, smoking and smokeless tobacco use were inversely associated with hypertension for both males and females. These findings are contrary to the existing evidence that smoking causes adverse cardiovascular events and increases the risk of coronary heart diseases in a combined role with hypertension and dyslipidemia [44]. This finding may be due to the reverse causation because the participants might have given up the habit of smoking due to their age and known hypertension status, and we collected the data only on current smoking status. At least one study suggested that to see the proper effects of smoking on hypertension; smoking data should be collected in a life-course approach as the effects of smoking may not appear immediately after starting or quitting smoking [45]. In our analysis, fruits and vegetable consumption also was not found significantly associated with hypertension in both sexes. In the case of hypertension, fruit and vegetable consumption usually helps with increased potassium intake. But in Bangladesh, improper processing, such as washing after cutting or over-cooking, may reduce the amount of potassium [46 47]. Also, not all fruits and vegetables have a high level of potassium. However, this should be studied further to explore causal pathway between hypertension and smoking, tobacco, fruits, and vegetables.

Among other factors, education was positively associated with hypertension. Elderly males with more than ten years of education had almost two times higher odds of having hypertension compared to those without any formal education. Education levels may elevate wealth status, which makes the people used to a sedentary lifestyle, and eventually may increase the risk of hypertension [48]. However,

the wealth index didn't show any such clear pattern, although elderlies in the upper wealth quintiles had a relatively higher prevalence of hypertension. In this study, living in slums was associated with lower odds of hypertension. Self-reported diabetes was also found positively associated with hypertension in both males and females in this age group of the population, which is supported by several studies in Bangladesh and elsewhere [49-51].

Strengths and limitations

Prevalence of hypertension among elderly people was reported in several studies in Bangladesh, but to the best of our knowledge, this is the first-ever nationally representative survey in Bangladesh investigating the prevalence and associated factors of hypertension among the elderly people. The limitations of the study include sampling challenges at the field level. The data collectors faced higher refusal rates in wealthier non-slum urban areas and a few isolated rural communities. Besides, seven selected rural clusters were dropped from the survey due to administrative and financial constraints, which may affect the national representativeness in the study. Among other limitations, blood pressure measurements were taken on a single day rather than longitudinal measurements on different days to confirm the diagnosis of hypertension. Also, the associations we have found in our study might not be causal due to lack of temporality, as the study was a cross-sectional one. Besides, we could not adjust for some strong confounders, such as salt consumption, genetic factors [52 53]. However, these limitations emphasize the importance of further research on the determinants of hypertension among the elderly people of Bangladesh. We also recommend studying the sex difference in the physiology and pathophysiology of hypertension by exploring the effects of gonadal hormones and sex chromosomes on blood pressure to yield customized management of hypertension separately for both males and females.

Conclusions

As per the findings of our study, about half of the Bangladeshi elderlies were hypertensive, and hypertension was more prevalent among elderly females. Common factors associated with hypertension for both sexes were age, insufficient physical activity, central obesity, and self-reported diabetes. Education was also positively associated with hypertension in males. Risk factors such as insufficient physical activity and obesity are largely modifiable by appropriate education and control programs with support from the health and other sectors of the government. The early diagnosis of hypertension and other health problems is critical for controlling hypertension and the prevention of hypertension-related complications. However, the sex difference in the prevalence of and factors associated with hypertension indicated that a common prevention and control strategy might not work in this age group of population. Rather, the government should design a specific screening and control program to reduce the number of cases by early diagnosis and control and eventually minimize further

complications of hypertension. Besides, education programs should immediately be initiated to raise awareness among the elderly males and females as well as their family members on healthy lifestyles. The introduction of geriatric health care with the general health care system at the primary health care level can be an important step in improving the overall health of elderly people.

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Table 1: Background characteristics of the study population by sex

Variables	Overall		Male		Female		p-value
	N=4,817		N=2,482		N=2,335		
	n	%	n	%	n	%	
Age Group							<0.001
60 to 69 years	3,225	67.0	1,725	69.5	1,500	64.3	
70+ years	1,591	33.0	757	30.5	834	35.7	
No	4,238	88.0	2,212	89.1	2,026	86.8	
Yes	579	12.0	270	10.9	309	13.2	
Place of Residence							0.003
Rural	3,463	71.9	1,835	73.9	1,628	69.7	
Non-slum urban	807	16.8	394	15.9	413	17.7	
Slum	547	11.4	253	10.2	294	12.6	
Educational status							<0.001
No education	3,014	62.6	1,214	48.9	1,800	77.1	
Up to primary	558	11.6	342	13.8	216	9.3	
Up to SSC	843	17.5	567	22.8	276	11.8	
Above SSC	402	8.3	359	14.5	43	1.8	
Wealth Quintile							0.016
Least wealthy (Q1)	966	20.1	543	21.9	423	18.1	
Lower (Q2)	969	20.1	485	19.5	484	20.7	
Middle (Q3)	963	20.0	494	19.9	469	20.1	
Upper (Q4)	958	19.9	491	19.8	467	20.0	
Wealthiest (Q5)	960	19.9	469	18.9	491	21.0	
Marital Status							<0.001
Currently married	2,861	59.4	2,277	91.7	584	25.0	
Others*	1,956	40.6	205	8.3	1,751	75.0	
Religion							0.29
Muslim	4,075	84.6	2,113	85.1	1,962	84.0	
Others**	742	15.4	369	14.9	373	16.0	
Physical Activity							0.026
>=150 Minutes/week	2,707	56.2	1,433	57.7	1,274	54.6	
<150 Minutes/week	2,110	43.8	1,049	42.3	1,061	45.4	
Fruits & Vegetables Consumption							<0.001
>=5 servings/day	450	9.3	320	12.9	130	5.6	
<5 servings/day	4,367	90.7	2,162	87.1	2,205	94.4	
Currently smoking							<0.001
No	3,828	79.5	1,564	63.0	2,264	97.0	
Yes	989	20.5	918	37.0	71	3.0	
Smokeless tobacco use							<0.001
No	2,438	50.6	1,455	58.6	983	42.1	
BMI Category (Asian)							<0.001
Normal	2,077	45.1	1,145	47.5	932	42.4	
Underweight	1,100	23.9	589	24.4	511	23.2	
Overweight	1,084	23.5	554	23.0	530	24.1	

Obese	347	7.5	121	5.0	226	10.3	
Waist Circumference							<0.001
Male: <90 cm Female: <80 cm	3,227	68.5	1,887	77.1	1,340	59.1	
Male: >= 90 cm Female: >=80 cm	1,487	31.5	560	22.9	927	40.9	
Self-reported diabetes							0.012
Yes	2,379	49.4	1,027	41.4	1,352	57.9	

*Never married, widows, divorced and separated
**Hindu, Christian, Buddhist and others

Table 2: Prevalence of hypertension according to background characteristics among elderly males and females (weighted) with 95% Confidence Interval

Variables	Overall	Male	Female
	% (95% CI)	% (95% CI)	% (95% CI)
Overall	49.0 (45.2, 52.9)	42.4 (37.4, 47.6)	56.3 (52.1, 60.4)
Age Group (in Years)			
60 to 69 years	47.6 (43.9, 51.4)	40.7 (35.3, 46.3)	55.2 (50.2, 60.0)
70 years and above	51.5 (45.4, 57.6)	45.5 (37.9, 53.3)	58.4 (52.9, 63.7)
Place of Residence			
Rural	49.0 (45.0, 52.9)	42.4 (37.3, 47.7)	56.2 (51.9, 60.5)
Non-slum urban	53.1 (48.4, 57.8	44.9 (38.5, 51.4)	62.9 (57.7, 67.8)
Slum	39.7 (32.4, 47.4)	29.7 (24.0, 36.1)	50.3 (40.9, 59.6)
Educational status			
No education	46.9 (42.6, 51.2)	34.4 (29.2, 40.0)	55.6 (51.0, 60.2)
Up to primary	49.0 (40.3, 57.8)	44.1 (31.8, 57.2)	57.1 (47.4, 66.2)
Up to SSC	50.6 (45.0, 56.1)	47.4 (41.0, 53.8)	58.8 (47.3, 69.5)
Above SSC	66.8 (58.3, 74.3)	65.7 (56.8, 73.6)	81.2 (48.5, 95.2)
Wealth Quintile			
Least wealthy (Q1)	44.9 (38.8, 51.1)	39.3 (31.9, 47.1)	52.4 (43.5, 61.1)
Lower (Q2)	48.4 (43.8, 53.0)	39.0 (33.9, 44.3)	57.5 (51.4, 63.3)
Middle (Q3)	51.2 (45.3, 57.1)	45.1 (38.1, 52.2)	58.2 (50.4, 65.7)
Upper (Q4)	46.4 (38.0, 55.1)	41.2 (31.5, 51.8)	52.2 (41.1, 63.1)
Wealthiest (Q5)	56.5 (51.2, 61.7)	51.3 (44.6, 57.8)	61.7 (51.9, 70.6)
Marital Status			
Currently married	44.9 (40.7, 49.2)	41.4 (36.3, 46.8)	54.0 (48.2, 59.7)
Others**	57.8 (53.6, 61.9)	57.8 (48.6, 66.4)	57.8 (53.2, 62.3)
Religion			
Muslim	48.5 (44.0, 53.0)	41.7 (36.0, 47.6)	56.1 (51.3, 60.8)
Others***	51.6 (47.4, 55.8)	46.0 (39.0, 53.2)	57.3 (52.5, 62.1)
Physical Activity			
>=150 Minutes/week	44.6 (40.9, 48.3)	36.5 (31.3, 42.0)	53.8 (49.6, 57.9)
<150 Minutes/week	56.2 (51.0, 61.2)	52.3 (45.6, 59.0)	60.1 (53.9, 66.1)
Fruits & Vegetables Consumption			
>=5 servings/day	44.7 (36.6, 53.0)	37.0 (27.4, 47.7)	62.6 (50.9, 73.0)
<5 servings/day	49.5 (45.5, 53.4)	43.2 (38.2, 48.3)	55.9 (51.4, 60.3)
Current smokers			
No	52.2 (48.2, 56.3)	46.7 (41.1, 52.3)	56.4 (52.1, 60.6)

Yes	34.8 (29.9, 40.1)	33.9 (28.5, 39.7)	52.2 (36.0, 68.0)
Smokeless tobacco use			
No	49.3 (44.7, 53.8)	42.3 (36.9, 47.8)	59.1 (52.3, 65.6)
Yes	48.8 (44.5, 53.1)	42.5 (36.1, 49.3)	54.3 (49.7, 58.8)
Body Mass Index			
Normal	46.5 (42.2,50.8)	38.5 (33.5,43.9)	56.3 (50.7,61.8)
Underweight	32.9 (27.3,39.0)	30.0 (22.3,39.1)	36.6 (29.9,43.8)
Overweight	64.2 (58.9,69.1)	60.2 (54.4,65.7)	68.0 (59.5,75.4)
Obese	74.8 (64.3,83.0)	72.5 (57.7,83.6)	76.4 (62.6,86.3)
Waist Circumference			
Males <102 cm; Females <88 cm	41.7 (37.3,46.1)	36.6 (31.4,42.1)	48.9 (43.4,54.4)
Males ≥102 cm; Females ≥88 cm	67.8 (63.7,71.6)	65.4 (58.4,71.8)	69.2 (63.0,74.7)
Self-reported diabetes			
No	47.5 (43.8, 51.1)	40.9 (36.0, 46.0)	54.9 (51.1, 58.7)
Yes	64.9 (55.2, 73.5)	60.5 (49.6, 70.5)	68.5 (56.2, 78.7)

¥Test was done between hypertension (Yes vs. No) and sex (Male vs. Female) for each row; CI: Confidence Interval
*Statistically significant
**Never married, widows, divorced and separated
***Hindu, Christian, Buddhist and others

Table 3: Factors associated with hypertension among elderly Bangladeshi people stratified by sex

Variables	Male				Female			
	COR	95% CI	AOR	95% CI	COR	95% CI	AOR	95% CI
Age (in Years)								
60 to 69	Ref		Ref		Ref		Ref	
70+	1.42***	1.19, 1.68	1.32**	1.09, 1.60	1.39***	1.17, 1.66	1.40**	1.15, 1.71
Place of Residence								
Rural	Ref		Ref		Ref		Ref	
Non-slum urban	1.72***	1.38, 2.15	0.93	0.69, 1.23	1.87***	1.48, 2.37)	1.18	0.88, 1.59
Slum	0.76	0.58, 1.00	0.71*	0.52, 0.96	0.88	0.69, 1.13	0.89	0.67, 1.17
Educational status								
No education	Ref		Ref		Ref		Ref	
Up to primary	1.07	0.84, 1.37	0.92	0.71, 1.19	1.00	0.75, 1.33	0.95	0.70, 1.28
Up to SSC	1.62***	1.32, 1.98	1.25*	1.00, 1.56	1.71***	1.30, 2.25	1.27	0.94, 1.72
Above SSC	3.12***	2.44, 3.99	1.83***	1.38, 2.44	3.79**	1.68, 8.57	2.41	0.97, 6.00
Wealth Quintile								
Least wealthy	Ref		Ref		Ref		Ref	
Lower	0.95	0.74, 1.23	0.95	0.73, 1.24	1.28	0.98, 1.66	1.25	0.95, 1.64
Middle	1.37*	1.07, 1.75	1.19	0.91, 1.55	1.41*	1.08, 1.84	1.32	1.00, 1.75
Upper	1.23	0.96, 1.57	0.94	0.71, 1.23	1.19	0.91, 1.55	0.94	0.71, 1.26
Wealthiest	1.75***	1.36, 2.25	0.94	0.69, 1.28	1.66***	1.27, 2.16	1.04	0.76, 1.44
Marital Status								
Currently married	Ref		Ref		Ref		Ref	
Others**	1.37*	1.03, 1.82	1.13	0.82, 1.56	1.23*	1.02, 1.49	1.03	0.84, 1.28
Religion								

Muslim	Ref		Ref		Ref			
Others***	1.28	1.03, 1.60	1.18	0.93, 1.51	0.99	0.79, 1.24	NA	NA
Physical Activity								
≥150 minutes/week	Ref		Ref		Ref		Ref	
<150 minutes/week	1.95***	1.66, 2.29	1.50***	1.25, 1.81	1.72***	1.45, 2.03	1.38**	1.15, 1.67
Fruits & Vegetables								
≥5 servings/day	Ref		Ref		Ref			
<5 servings/day	1.35*	1.06, 1.72	1.24	0.95, 1.60	0.98	0.68, 1.40	NA	NA
Current smoker (for ≥30 days)								
No	Ref		Ref		Ref		Ref	
Yes	0.55***	0.47, 0.65	0.74**	0.61, 0.89	0.65	0.41, 1.05	0.69	0.42, 1.15
Smokeless tobacco user (for ≥30 days)								
No	Ref		Ref		Ref		Ref	
Yes	0.80**	0.68, 0.94	0.86	0.72, 1.02	0.74**	0.63, 0.88	0.87	0.72, 1.04
Body Mass Index (BMI)								
Normal	Ref		Ref		Ref		Ref	
Underweight	0.62***	0.50, 0.77	NA	NA	0.56***	0.45, 0.69	NA	NA
Overweight	2.25***	1.83, 2.77	NA	NA	1.69***	1.35, 2.12	NA	NA
Obese	4.53***	2.96, 6.93	NA	NA	2.99***	2.10, 4.25	NA	NA
Waist Circumference								
Males <102 cm; Females <88 cm	Ref		Ref		Ref		Ref	
Males ≥102 cm; Females ≥88 cm	3.39***	2.78, 4.14	2.76***	2.22, 3.43	2.46***	2.06, 2.94	2.20***	1.82, 2.67
Self-reported Diabetes								
No	Ref		Ref		Ref		Ref	
Yes	2.22***	1.72, 2.88	1.36*	1.02, 1.82	2.45***	1.85, 3.23	1.82***	1.35, 2.45

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; CI: Confidence Interval; COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio; NA: Not applicable, these variables were not included in the adjusted analysis as these were dropped due to the significance level was >0.2 in the crude analysis or due to high correlation with a covariate.

Figure 1:

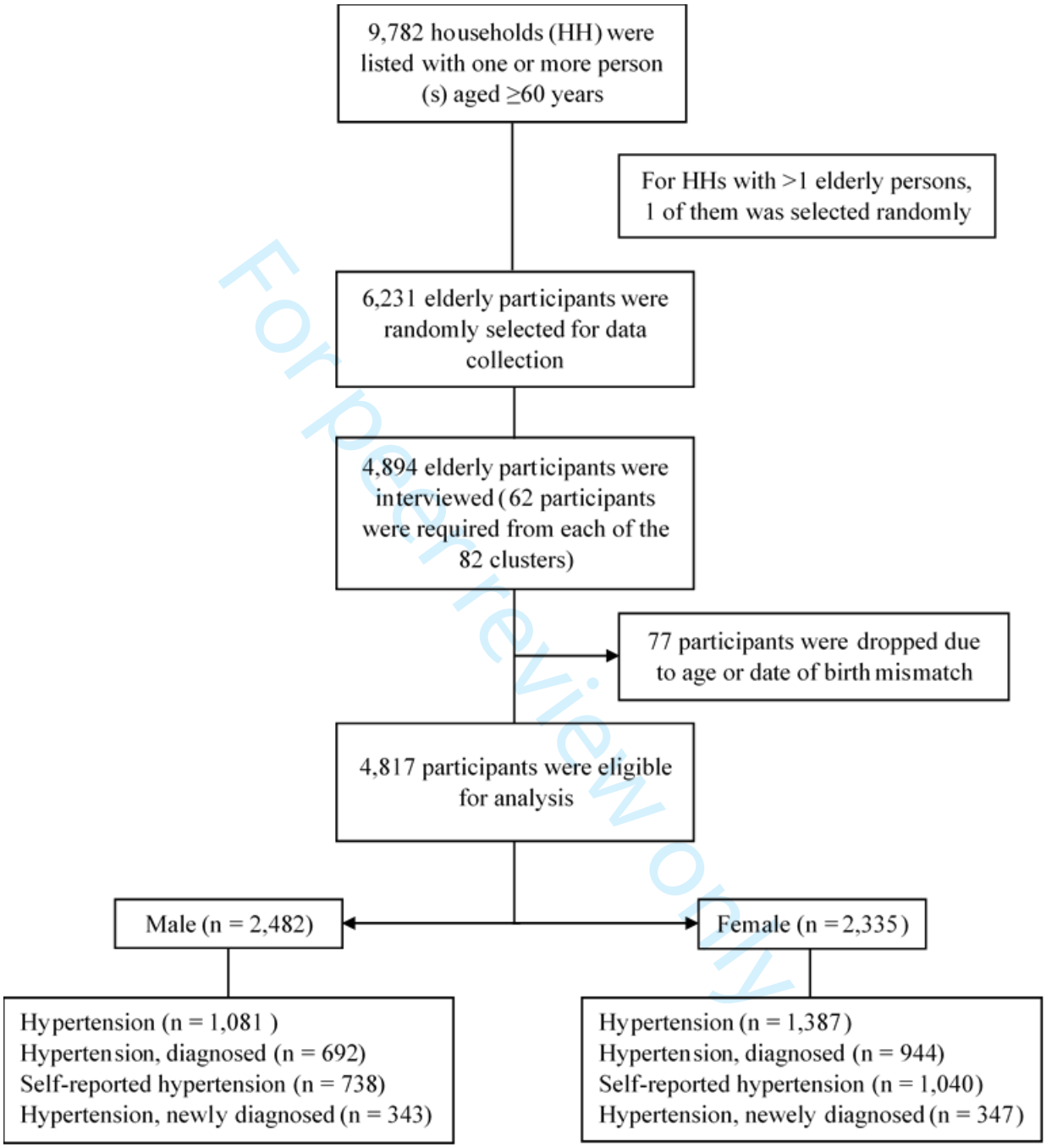

Figure 1: Study flow chart of participants selection (aged ≥60 years)

Figure 2:

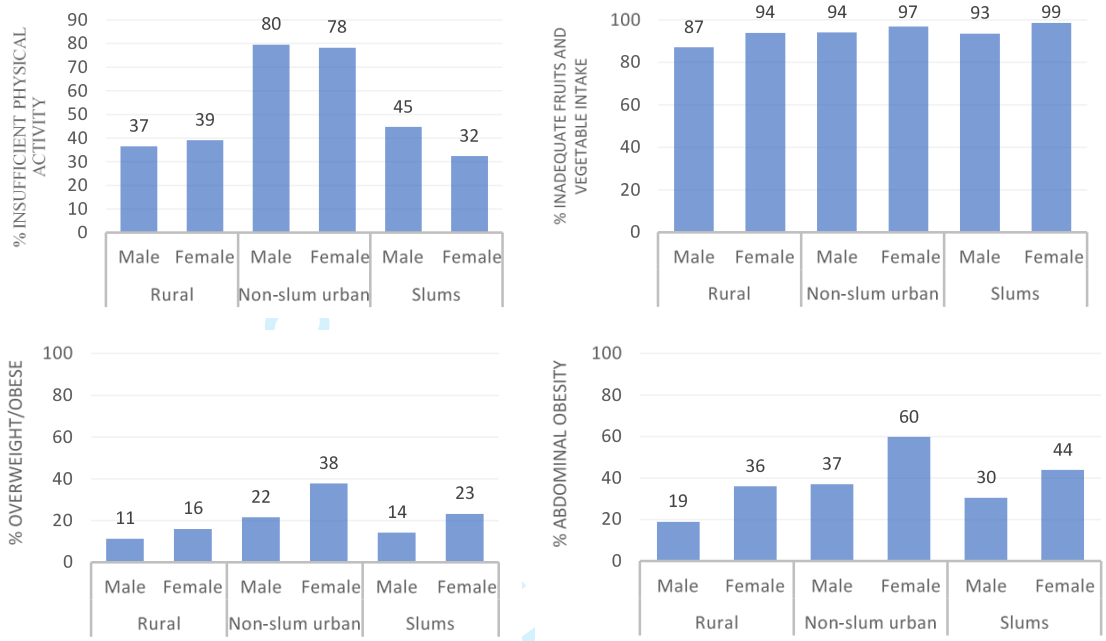

Figure 2: Selected behavioral and clinical characteristics by area of residence and gender

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	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2-3
Objectives	3	State specific objectives, including any prespecified hypotheses	2-3
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4-5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
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	5-6
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable
		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*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	5
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	5
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-8
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	7-8
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	7-9
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*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	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	7-8
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	12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-12
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	16

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

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

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Gender-specific prevalence and associated factors of hypertension among elderly Bangladeshi people: findings from a nationally representative cross-sectional survey

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Abstract

Objective: We aimed to estimate the gender-specific prevalence and associated factors of hypertension among elderly people in Bangladesh.

Design and method: We analyzed data from the food security and nutrition surveillance round 2018-19. The multistage cluster sampling method was used to select the study population. Hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg and/or having a history of hypertension. We carried out the descriptive analysis, bivariate and multivariable logistic regression to report the weighted prevalence of hypertension as well as crude and adjusted odds ratios with 95% confidence interval. A p-value <0.05 was considered statistically significant.

Setting: The study was conducted in 82 clusters (57 rural, 15 non-slum urban, and 10 slums) in all 8 administrative divisions of Bangladesh.

Participants: A total of 2,482 males and 2,335 females aged ≥60 years were included in the analysis.

Results: The weighted prevalence of hypertension was 42% and 56% among males and females, respectively. The prevalence was higher among females across all sociodemographic, behavioral, and

biological strata. Factors associated with higher odds of hypertension in both sexes were age 70+ years [AOR with 95%CI: 1.37(1.13,1.66) for males and 1.40(1.15,1.70) for females]; education above 10th grade [AOR with 95%CI: 1.98(1.49,2.63) for males and 2.50(1.01,6.21) for females]; insufficient physical activity [AOR with 95%CI: 1.53(1.27,1.83) and 1.40(1.17,1.69)]; abdominal obesity [AOR with 95%CI: 2.81(2.26,3.49) and 2.21(1.82,2.67)]; and self-reported diabetes [AOR with 95%CI: 1.40(1.05,1.87) and 1.83(1.36,2.46)]. Additionally, living in slums decreased odds of hypertension [AOR with 95%CI: 0.68(0.50,0.92)] among males.

Conclusion: In Bangladesh, half of the elderly were hypertensive, with a higher prevalence in females. Odds of hypertension was increased by older age (≥70 years), education >10 years, insufficient physical activity, abdominal obesity, and self-reported diabetes. The Ministry of Health of Bangladesh should consider this while designing and implementing health programs.

Keywords: Hypertension, elderly people, prevalence, Bangladesh

Strengths and limitations of this study

- Information on the prevalence, sex-difference, and associated factors of hypertension among the elderly Bangladeshi population are scarce.
- The nationally representative design allowed the objective assessment of the prevalence, sex-difference, and factors of hypertension among the elderly Bangladeshi population.
- Blood pressure was measured on a single day rather than longitudinal measurements to confirm the diagnosis of hypertension.
- The associations might not be causal due to lack of temporality, as the study was a cross-sectional one.
- Some strong confounders such as salt consumption, tobacco consumption, genetic factors could not be addressed.

Introduction

The proportion of the aging population around the world is rapidly increasing, and the pace is faster than ever. The global population aged ≥60 years reached 962 million in 2017, more than double compared to 1980 and is projected to double again by 2050 when it reaches 2.1 billion [1]. In another estimate, globally, the population aged ≥60 years will be 22% by the year 2050, and 80% of which will live in low and middle-income countries [2]. In 2017, 8.8% of the South Asian population was aged ≥60 years, which is projected to be 18.9% by 2050 [1]. Despite its arbitrary nature, persons aged ≥65 years are considered as elderly in most of the developed countries [3]. However, in Bangladesh, persons aged ≥60 years are considered as elderly people considering the shorter longevity [4]. Bangladesh witnessed a five-fold increase in the elderly population between 1974 and 2001 [5]. According to the Bangladesh Bureau of Statistics, about 12.5 million (7.5%) of Bangladeshi people were elderly in 2019, which is expected to be 40 million (20%) by the year 2050 [6].

Hypertension or raised blood pressure is a condition when the pressure of blood flow on the vessel walls become higher than normal [7]. People often are not aware of whether they are hypertensive or not, and hence it is often called the "silent killer" [8]. Globally, hypertension is one of the major causes of deaths and disabilities. According to the World Health Organization Global Health Observatory (GHO) 2016 data, 7.5 million annual deaths were estimated to be caused by high blood pressure, which was about 12.8% of total deaths worldwide. Hypertension is also accounted for 57 million disability-adjusted life years (DALYs), which amounts to 3.7% of total DALYs [9]. Globally, hypertension is responsible for 45% of deaths from cardiac causes, and 51% of the deaths from stroke [10]. As a risk factor, hypertension causes nearly 30% of all cardiovascular disease [11].

The prevalence of hypertension substantially increases with age. Evidence from the Framingham heart study, the longest-standing study on cardiovascular disease epidemiology, showed that more than 90% of the people who remain normotensive (systolic blood pressure <120 mmHg and diastolic blood pressure < 80 mmHg) at the age of 65 years would develop hypertension (systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥90 mmHg) at their remaining life-span, may be due to age-related vascular changes [12]. Kibria et al. analyzed data from the Bangladesh Demographic and Health Survey 2011 (BDHS 2011) and reported that 30% of the males and 52% of the females aged ≥65 years were hypertensive, along with 25% of both sexes of the same age group were prehypertensive (SBP 120-139 mmHg; DBP 80-89 mmHg)[13]. Another study reported that an estimated 23% of the elderly people in rural Bangladesh had undiagnosed hypertension (those who had no known hypertension but found hypertensive upon measurement), and among those who were diagnosed and were receiving treatment, 68% had uncontrolled hypertension (blood pressure above the normal range despite antihypertensive treatment) [14].

Despite these facts, hypertension among elderly people in this region could not gain enough attention. One of the reasons can be limited information due to poor or no screening and control measures for hypertension among the elderly population. To the best of our knowledge, there is no study reporting national prevalence and associated risk factors of hypertension among the elderly Bangladeshi population of 60 years and above. Even some studies have excluded older adults who are at higher risk of NCDs. Accordingly, the objective of our study is to report the prevalence and factors associated with hypertension among elderly males and females of Bangladesh.

Materials and Methods

Study design and site

We conducted a cross-sectional survey among six population groups (children <5 years, adolescent boys, adolescent girls, adult females, adult males, and elderly people). Our objective was to generate nationally and divisionally representative estimates of different nutrition and health-related variables, including major noncommunicable diseases in elderly males and females. The data collection period was from October 2018 through October 2019. In this nationally representative study, we enrolled participants from all eight administrative divisions (Barisal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, and Sylhet) and covered rural, non-slum urban and slum areas. We enrolled in study subjects from 82 randomly selected clusters (57 rural, 15 non-slums urban, and 10 slums).

Sample size and sampling techniques

We determined the sample size to generate nationally, and divisionally representative prevalence for the selected indicators with prevalence ranged from 4% to 98% using a multistage cluster sampling. We considered the type I error, $\alpha = 0.05$; allowable margin of error, $d = 0.05$ (or d = prevalence/2 if prevalence ≤ 0.1); design effect, DEF = 1.61 and calculated a sample size of 62 elderly individuals from each cluster. Accordingly, the sample size for the elderly population was 5,580 from 90 clusters in the country. Finally, we could complete collecting data from 82 clusters and obtained a sample size of 4,894 elderly people.

Separate sampling designs were applied to select the study sites in rural, urban, and slum areas. For the rural area, two districts were first selected from each division in the first stage of four-stage sampling. From each district, two sub-districts (Upazilla) were randomly selected. In the third stage, two unions were randomly chosen from each of the selected sub-districts. The villages/mouzas/geographically demarcated segments with 250-400 households were then identified and mapped. Finally, we randomly selected two of the listed village/mouza/segments from each union as study clusters.

In the urban areas, we used the population proportion of Bangladesh Bureau of Statistics (BBS) 2011 census [15]. We randomly selected 16 wards (1-2 wards/division). We then identified the Mahalla (similar to the villages) with more than 250 households, and the mahallas with >500 households were further sub-divided into smaller geographically demarcated segments of ~250 households. We randomly picked one segment from the listed segments from the selected wards, and that was our study cluster.

In the slum areas, the Census of Slum Areas and Floating Population 2014 was used for the selection of study sites [16]. Slums having ≥ 300 households were identified, and those with >500 households were further divided into smaller segments. Two segments from the Dhaka and Chattogram divisions and one from each of the other six divisions were randomly selected as study clusters.

For each cluster, data collectors first listed all households with individuals aged ≥60 years. A statistician then selected 80 households from the list using Simple Random Sampling to enroll 62 elderly people from a cluster. After selecting the households from a cluster, if there was any household with more than one person aged ≥60 years, we randomly selected one of them using the simple random sampling method. Figure 1 demonstrates how the participants were selected in the study.

Figure 1: Study flow chart of participants selection (aged ≥60 years)

Data Collection

We collected data using a structured questionnaire, developed initially in English, and then translated into the local language. Data were collected using face to face interviews and physical measurements and were directly entered in tablet computers (Samsung Galaxy Tab A7) using a customized SurveyCTO application [17]. At the end of everyday data collection, data collectors uploaded all the collected data to the server. We measured the height (using locally made portable stadiometer), weight (using TANITA UM-070 weighing scale), waist circumference (using measuring tape), and blood pressure (using Omron HEM 7120) of the elderly people.

To collect data on self-reported hypertension, the data collector(s) asked the participant the following question - “Has a health care provider ever told you that you have high blood pressure, also called hypertension (other than during pregnancy)?” Before measuring blood pressure, the data collector ensured that the participant was in a resting condition for at least 15 minutes. There was a three minutes

interval between two subsequent measurements. If there was a gap of ≥10 mmHg between the first two measurements of either systolic or diastolic blood pressure or both, a third measurement was taken.

Anthropometric measurements were taken based on WHO guidelines, as specified in the Food and Nutrition Technical Assistance (FANTA) anthropometry manual [18]. The weight was measured to the nearest 0.1 kg with light cloths, and height was measured to the nearest 0.1 cm in the standing position with no shoes. Waist circumference was measured to the nearest 0.1 cm at the end of a normal expiration, at the midpoint between the lower part of the last rib and the top of the hipbone, with the arms relaxed at the sides. Usually, we took two measurements of weight, height, and waist circumference, and if the gap between the two first measurements were >0.1 kg for weight and >0.5 cm for height and waist circumference, we took the third measurement.

Operational definitions

The outcome variable in our analysis was the hypertension status of elderly males and females. Hypertension was defined as systolic blood pressure ≥140 mmHg, or diastolic blood pressure ≥90 mmHg or if the participants were told as hypertensive by any trained health care provider (self-reported) [19]. The variable was made dichotomous either as hypertensive (measured or self-reported) or as non-hypertensive to facilitate logistic regression.

We made a list of potential factors associated with hypertension among elderly people based on literature review and types of data collected by the survey. The socioeconomic factors were age (60-69 years vs. 70+ years), place of residence (rural, non-slum urban, and slum), education (no formal education, up to primary level, up to 10 completed years and >10 completed years), wealth status, marital status (currently married vs. never married, divorced, widowed or separated), and religion (Muslim vs. others).

The behavioral factors were physical activity, fruits, and vegetable consumption (≥5 servings/day vs. <5 servings). An elderly person was considered doing sufficient physical activity (during work, transport, and recreational activities), if he or she reported at least 150 minutes of moderate-intensity physical activity per week or 75 minutes of heavy physical activity per week or equivalent [20].

Body mass index, waist circumference, and self-reported diabetes were the anthropometric and clinical factors. We used the Asian cutoff to categorize Body Mass Index (BMI) into underweight (<18.5 kg/m2), normal (≥18.5 to <23.0 kg/m2), overweight (≥23.0 to <27.5 kg/m2, and obese (≥27.5 kg/m2) [21]. Abdominal obesity was defined as the waist circumference of ≥90 cm in males and ≥80 cm in females [22]. For this analysis, we considered the average of the two closest measurements for blood

pressure and all anthropometric variables. Self-reported diabetes was documented if any participant reported that a trained health care provider ever told him or her that he or she had diabetes.

Quality Assurance and Control

Data collectors and the field supervisors received extensive training on interviews, anthropometric measurements, and maintenance of data collection instruments and had gone through a rigorous standardization procedure. We field-tested the questionnaire, modified it, and refreshed the data collectors based on the findings of field testing. To ensure data quality, the field supervisors directly observed 5% of the interviews and re-interviewed another 5% of the randomly selected participants within 48 hours of the initial visit. Interim analyses were performed to check the data quality. All the measuring tools were calibrated routinely.

Statistical Analysis

We performed all the data analysis using Stata 15.1 (Stata Corp, College Station, TX, USA) [23]. All the background characteristics are reported as categorical variables. We performed principal component analysis (PCA) to calculate wealth quintiles of the households of the participants. We estimated the weighted prevalence of hypertension for both elderly males and females. As the males and females differed by the distribution of risk factors and the prevalence of hypertension, we conducted separate bivariate and multivariable logistic regression, respectively, to identify the factors associated with hypertension. The variables with a p-value of ≤0.2 in the crude analysis were included in the multivariable logistic regression model a[24]. Variance inflation factors (VIFs) were also checked to assess multi-collinearity among variables. We included both BMI and waist circumference separately in our initial analysis as both are important predictors of hypertension. But finally, we used the waist circumference in the regression model due to its high correlation with BMI ($r = 0.87$, $P < 0.001$) as well as its program implications as waist circumference can be easily measured and interpreted for screening in a low resource setting. Crude and adjusted odds ratios were estimated at 95% confidence Intervals and the determinants with the p-value <0.05 were considered statistically significant.

Ethical considerations

The FSNSP 2018-19 obtained the ethical approval from the Institutional Review Board (IRB) of the BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh (IRB Reference number: 2018-020-IR). Written informed consent was taken from the respondents before data collection and measurements.

Results

Table 1 describes the characteristics of the study participants. The median (interquartile range) age of the participants was 65.8 (62.4, 71.8) years. The female participants were Of 48.4%, and the rural area contributed 72.0% of the study subjects. More females (77.1%) were identified without any formal education compared to their male counterparts (48.9%). Only one in every four females and 92% of the males were found married at the time of the survey. Above one-third of the participants from both sexes (42% of males and 45% of females) reported insufficient physical activity. Daily fruits and vegetable consumption of 9 out of 10 elderlies were <5 servings. A higher proportion (34.4%) of females were overweight or obese than males (28.0%). Abdominal obesity was identified among 23% of males and 41% of females. About 11% of elderly males and 13% of elderly females reported having diabetes.

Table 1: Background characteristics of the study population by sex

Figure 2 demonstrates the distribution of a few selected behavioral and clinical characteristics across the places of residence and sexes. In our study, the prevalence of these risk factors is higher among elderly females compared to their male counterparts except for insufficient physical activity in urban areas. Almost 80% of males and 78% of females of the non-slum urban area reported performing an insufficient physical activity, which is around 40% in both rural and slum areas. Overall, 91% of the elderly were consuming inadequate fruits and vegetables, which was 94% in females and 87% in males. However, above 98% of slum women failed to consume the recommended servings of fruits and vegetables. Overweight/obesity was also highest in urban females, which was about 38% compared to 22% in urban males. Similarly, 60% of urban females were identified with abdominal obesity.

Figure 2: Selected behavioral and clinical characteristics by area of residence and gender

Table 2 shows the prevalence of hypertension according to the characteristics of the participants and how it differs between males and females. In total, more females (56%) were identified as hypertensive than males (42%). Urban elderly females had the highest prevalence of hypertension (63%), whereas the male slum dwellers had the lowest (30%). The wealthiest of the population had the highest prevalence of hypertension in both sexes (51% in males and 62% in females). Married elderly males had a lower prevalence of hypertension (41%) compared to those who were not married during the

survey (58%). The prevalence of hypertension increased with age, education, body mass index, and waist circumference in both sexes. However, the prevalence of hypertension was lower among those who reported sufficient physical activity, and adequate consumption of fruits and vegetables.

Table 2: Prevalence of hypertension according to background characteristics among elderly males and females (weighted) with 95% Confidence Interval

We reported the results of bivariate and multivariable logistic regressions in **Table 3**. In bivariate analysis, we found that all the selected variables were significantly associated with hypertension in males, whereas in females, we found that age, place of residence, education, wealth index, marital status, physical activity, BMI, waist circumference and diabetes were significantly associated with hypertension. However, in multivariate analysis, we found that age ≥70 years [AOR with 95%CI: 1.37 (1.13,1.66) for males and 1.40 (1.15,1.70) for females] compared to 60-69 years; education above 10th grade [AOR with 95%CI: 1.98 (1.49,2.63) for males and 2.50 (1.01,6.21) for females] compared to those with no formal education; insufficient physical activity [AOR with 95%CI: 1.53 (1.27,1.83) and 1.40 (1.17,1.69)] compared to recommended amount of physical activity; abdominal obesity [AOR with 95%CI: 2.81 (2.26,3.49) and 2.21 (1.82,2.67)] with refer to no abdominal obesity i.e. normal waist circumference (Male: <90 cm/ Female: <80 cm); and self-reported diabetes [AOR with 95%CI: 1.40 (1.05,1.87) and 1.83 (1.36,2.46)] compared to no reported diabetes. Additionally, living in slums decreased odds of hypertension [AOR with 95%CI: 0.68 (0.50,0.92)] among males compared to rural residents. We also ran an alternative multivariable logistic regression model including BMI as an independent variable and provided the results in **supplementary table 1.**

Discussion

In our study, the overall prevalence of hypertension among the elderly people of Bangladesh was 49%, which is similar to the south Asian prevalence of hypertension among elderlies aged ≥65 years (53%) but lower than the average prevalence in the low and middle-income countries (66%) reported in a recent systematic review and meta-analysis [25]. The prevalence is still lower than the prevalence of hypertension in high-income countries. In a systematic analysis, Katherine et al. demonstrated that, in 2010, prevalence of hypertension among the high-income countries was 60.8% (male: 55.3%; female: 60.9%) and 73.6% (male: 65.6%; female: 77.5%) in the age groups 60-69 years and 70+ years, respectively [26]. However, our reported prevalence is higher than the prevalence previously estimated in Bangladesh demographic and health survey 2011, which was 35% and 40% for the age groups 60-69 and 70+ years, respectively [27]. The increase in the prevalence of hypertension may be due to recent

advancements in the economy and infrastructure of the country, leading the people into sedentary lifestyles and stress [28-30]. Hypertension is considered as the most important modifiable risk factor of cardiovascular diseases worldwide [31]. It has been shown that hypertension is responsible for nearly 30% of all cardiovascular diseases, and a person with hypertension has nearly three times the likelihood of having cardiovascular incidents compared to non-hypertensive individuals [11]. As a major contributor to cardiovascular diseases, hypertension causes a major proportion of ischemic heart diseases, heart failure, renal failure, as well as cerebrovascular diseases such as stroke [32]. As almost half of the population in the elderly age group in Bangladesh is hypertensive, we can indisputably assert that Bangladesh must take immediate steps to address this problem. Policymakers need to pay special attention while designing the screening and intervention program considering the health and wellbeing of the elderly people.

After segregating by sex, the prevalence of hypertension was 42% and 56% for males, and females, respectively. This higher prevalence among females is supported by several studies in Bangladesh and elsewhere [33]. It may be due to a lack of ovarian hormones during the postmenopausal period. Studies suggested that ovarian hormones, especially estrogen, may have the potentials to keep the blood pressure lower in premenopausal women, and lack of it may be responsible for elevated blood pressure in postmenopausal women [34]. Moreover, our findings indicate that women, at their advanced age, become socially more vulnerable to hypertension. For example, three out of four elderly women did not have a spouse, and it may affect their health care seeking and treatment. The government should pay additional attention to design customized screening and awareness programs for elderly people with special attention to the vulnerability of women.

Our study corroborated the fact that the odds of developing hypertension increases with age in both sexes. Studies conducted in Bangladesh [13], India [35], Pakistan [36], Nepal [37], Indonesia [38], and China [39], have shown that the older age group had a higher prevalence of hypertension. The biological effect of the increased arterial resistance due to age-related changes in the arterial wall, i.e., thickening of the arterial wall in old ages, may contribute to high-risk of hypertension in older ages [40]. Bangladesh is in the midst of a huge demographic transition, and with the decreasing trend of birth and death rate, the proportion of the elderly population is growing, which will eventually add more hypertensive patients and create more pressure on the already over-burdened health system of the country. In this study, insufficient physical activity increased the odds of having hypertension in both sexes. Elderlies, who reported less than 150 minutes of moderate-intensity or equivalent physical activity per week, had around 1.5 times more odds of having hypertension compared to those with 150 minutes or more such physical activity. This finding is supported by numerous studies [13 37 41]. Besides, physical inactivity was also found associated directly with stroke and ischemic heart diseases [42]. Elderly males and females with higher waist circumference had three times and two times more odds of having

hypertension, respectively, with refer to those with lower or normal waist circumference. Several studies have reported that waist circumference, as it represents abdominal obesity, is a better predictor of hypertension compared to BMI [43 44].

In our analysis, fruits and vegetable consumption was not found significantly associated with hypertension in both sexes. In the case of hypertension, fruit and vegetable consumption usually helps with increased potassium intake. But in Bangladesh, improper processing, such as washing after cutting or over-cooking, may reduce the amount of potassium [45 46]. Also, not all fruits and vegetables have a high level of potassium. However, this should be studied further to explore the causal pathway between hypertension and fruits & vegetables.

Among other factors, a higher level of education was responsible for the increased odds of having hypertension. Elderly males and females with more than ten years of education had about two times higher odds of having hypertension compared to those without any formal education. Kibria et al. found similar results analyzing the data from the Bangladesh Demographic and Health Survey 2011 [13]. Education levels may elevate wealth status, which makes the people used to a sedentary lifestyle, and eventually may increase the odds of hypertension [47]. However, the wealth index did not show any such clear pattern, although elderlies in the upper wealth quintiles had a relatively higher prevalence of hypertension [Table 2]. In this study, living in slums was associated with lower odds of hypertension though it was not statistically significant in the case of the females. Self-reported diabetes was also increased odds of having hypertension in both males and females in this age group of the population, which is supported by several studies in Bangladesh and elsewhere [48-50].

Recommendations

Risk factors such as insufficient physical activity and obesity are mostly modifiable by appropriate education and control programs with support from the health and other sectors of the government. The early diagnosis of hypertension and other health problems is critical for controlling hypertension and the prevention of hypertension-related complications. However, the sex difference in the prevalence of and factors associated with hypertension indicated that a universal prevention and control strategy might not work in this age group of population. Instead, the government should design a specific screening and control program to reduce the number of cases by early diagnosis and control and eventually minimize further complications of hypertension. Besides, education programs should immediately be initiated to raise awareness among the elderly males and females as well as their family members on healthy lifestyles. The introduction of geriatric health care with the general health care system at the primary health care level can be a crucial step in improving the overall health of elderly people.

Strengths and limitations

Prevalence of hypertension among elderly people was reported in several studies in Bangladesh. However, to the best of our knowledge, this is the first-ever nationally representative survey in Bangladesh investigating the prevalence and associated factors of hypertension among the elderly people. The limitations of the study include sampling challenges at the field level. The data collectors faced higher refusal rates in wealthier non-slum urban areas and a few isolated rural communities. Besides, seven selected rural clusters were dropped from the survey due to administrative and financial constraints, which may affect the national representativeness in the study. Among other limitations, blood pressure measurements were taken on a single day rather than longitudinal measurements on different days to confirm the diagnosis of hypertension. Also, the associations we have found in our study might not be causal due to lack of temporality, as the study was a cross-sectional one. Besides, we could not adjust for some strong confounders, such as salt consumption, genetic factors [51 52]. However, these limitations emphasize the importance of further research on the determinants of hypertension among the elderly people of Bangladesh. We also recommend studying the sex difference in the physiology and pathophysiology of hypertension by exploring the effects of gonadal hormones and sex chromosomes on blood pressure to yield customized management of hypertension separately for both males and females.

Conclusions

As per the findings of our study, about half of the Bangladeshi elderlies were hypertensive, and hypertension was more prevalent among elderly females in terms of sociodemographic, behavioral, and biological characteristics. Extreme old age (≥70 years), education above 10th grade, insufficient

physical activity, abdominal obesity (higher waist circumference), and self-reported diabetes was associated with increased odds of hypertension in Bangladeshi elderly population. Additionally, living in slums had lower odds of hypertension among elderly males. The government of Bangladesh should take a multisectoral approach involving health, economic, education, and social welfare sectors to promote healthy lifestyles among the elderly people and their families and provide emphasis on early diagnosis and treatment to prevent complications of hypertension among the elderly population.

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Table 1: Background characteristics of the study population by hypertension (no/yes) and sex (male/female)

Variables	Overall	Hypertension		Sex	
		No	Yes	Male	Female
	N=4,813	N=2,345	N=2,468	N=2,482	N=2,335
	n(%)*	n(%)*	n(%)*	n(%)*	n(%)*
Sex					
Male	2,482 (51.6)	1,401 (59.7)	1,081 (43.8)	--	--
Female	2,331 (48.4)	944 (40.3)	1,387 (56.2)	--	--
Age Group (in Years)					
60 to 69 years	3,223 (67.0)	1,668 (71.1)	1,555 (63.0)	1,725 (69.5)	1,500 (64.3)
70 years and above	1,589 (33.0)	677 (28.9)	912 (37.0)	757 (30.5)	834 (35.7)
Place of Residence					
Rural	3,463 (72.0)	1,757 (74.9)	1,706 (69.1)	1,835 (73.9)	1,628 (69.7)
Non-slum urban	806 (16.7)	292 (12.5)	514 (20.8)	394 (15.9)	413 (17.7)
Slum	544 (11.3)	296 (12.6)	248 (10.0)	253 (10.2)	294 (12.6)
Educational status					
No education	3,012 (62.6)	1,532 (65.3)	1,480 (60.0)	1,214 (48.9)	1,800 (77.1)
Up to 5th grade	556 (11.6)	302 (12.9)	254 (10.3)	342 (13.8)	216 (9.3)
Up to 10th grade	843 (17.5)	376 (16.0)	467 (18.9)	567 (22.8)	276 (11.8)
Above 10th grade	402 (8.4)	135 (5.8)	267 (10.8)	359 (14.5)	43 (1.8)
Wealth Quintile					
Least wealthy (Q1)	966 (20.1)	531 (22.7)	435 (17.6)	543 (21.9)	423 (18.1)
Lower (Q2)	968 (20.1)	500 (21.3)	468 (19.0)	485 (19.5)	484 (20.7)
Middle (Q3)	962 (20.0)	445 (19.0)	517 (20.9)	494 (19.9)	469 (20.1)
Upper (Q4)	957 (19.9)	475 (20.3)	482 (19.5)	491 (19.8)	467 (20.0)
Wealthiest (Q5)	959 (19.9)	393 (16.8)	566 (22.9)	469 (18.9)	491 (21.0)
Marital Status					
Currently married	2,860 (59.4)	1,558 (66.4)	1,302 (52.8)	2,277 (91.7)	584 (25.0)
Others**	1,953 (40.6)	787 (33.6)	1,166 (47.2)	205 (8.3)	1,751 (75.0)
Religion					
Muslim	4,073 (84.6)	2,005 (85.5)	2,068 (83.8)	2,113 (85.1)	1,962 (84.0)
Others***	740 (15.4)	340 (14.5)	400 (16.2)	369 (14.9)	373 (16.0)
Physical Activity					
>=150 Minutes/week	2,706 (56.2)	1,498 (63.9)	1,208 (48.9)	1,433 (57.7)	1,274 (54.6)
<150 Minutes/week	2,107 (43.8)	847 (36.1)	1,260 (51.1)	1,049 (42.3)	1,061 (45.4)
Fruits & Vegetables Consumption					
>=5 servings/day	450 (9.3)	253 (10.8)	197 (8.0)	320 (12.9)	130 (5.6)
<5 servings/day	4,363 (90.7)	2,092 (89.2)	2,271 (92.0)	2,162 (87.1)	2,205 (94.4)
BMI Category (Asian)					
Normal	2,077 (45.1)	1,098 (48.2)	979 (42.1)	1,145 (47.5)	932 (42.4)
Underweight	1,099 (23.9)	715 (31.4)	384 (16.5)	589 (24.4)	511 (23.2)
Overweight	1,084 (23.5)	390 (17.1)	694 (29.8)	554 (23.0)	530 (24.1)
Obese	345 (7.5)	76 (3.3)	269 (11.6)	121 (5.0)	226 (10.3)
Waist Circumference					
Male: <90 cm/ Female: <80 cm	3,226 (68.5)	1,859 (80.4)	1,367 (57.0)	1,887 (77.1)	1,340 (59.1)

Male: >= 90 cm/ Female: >=80 cm	1,485 (31.5)	452 (19.6)	1,033 (43.0)	560 (22.9)	927 (40.9)
Self-reported diabetes					
No	4,234 (88.0)	2,167 (92.4)	2,067 (83.8)	2,212 (89.1)	2,026 (86.8)
Yes	579 (12.0)	178 (7.6)	401 (16.2)	270 (10.9)	309 (13.2)

* Column percentages
** Never married, widows, divorced and separated
*** Hindu, Christian, Buddhist and others

Table 2: Prevalence of hypertension according to background characteristics among elderly males and females (weighted) with 95% Confidence Interval (CI)¥

Variables	Overall	Male	Female
	% (95% CI)	% (95% CI)	% (95% CI)
Overall	49.0 (45.2, 52.9)	42.4 (37.4, 47.6)	56.3 (52.1, 60.4)
Age Group (in Years)			
60 to 69 years	47.6 (43.9, 51.4)	40.7 (35.3, 46.3)	55.2 (50.2, 60.0)
70 years and above	51.5 (45.4, 57.6)	45.5 (37.9, 53.3)	58.4 (52.9, 63.7)
Place of Residence			
Rural	49.0 (45.0, 52.9)	42.4 (37.3, 47.7)	56.2 (51.9, 60.5)
Non-slum urban	53.1 (48.4, 57.8	44.9 (38.5, 51.4)	62.9 (57.7, 67.8)
Slum	39.7 (32.4, 47.4)	29.7 (24.0, 36.1)	50.3 (40.9, 59.6)
Educational status			
No education	46.9 (42.6, 51.2)	34.4 (29.2, 40.0)	55.6 (51.0, 60.2)
Up to 5th grade	49.0 (40.3, 57.8)	44.1 (31.8, 57.2)	57.1 (47.4, 66.2)
Up to 10th grade	50.6 (45.0, 56.1)	47.4 (41.0, 53.8)	58.8 (47.3, 69.5)
Above 10th grade	66.8 (58.3, 74.3)	65.7 (56.8, 73.6)	81.2 (48.5, 95.2)
Wealth Quintile			
Least wealthy (Q1)	44.9 (38.8, 51.1)	39.3 (31.9, 47.1)	52.4 (43.5, 61.1)
Lower (Q2)	48.4 (43.8, 53.0)	39.0 (33.9, 44.3)	57.5 (51.4, 63.3)
Middle (Q3)	51.2 (45.3, 57.1)	45.1 (38.1, 52.2)	58.2 (50.4, 65.7)
Upper (Q4)	46.4 (38.0, 55.1)	41.2 (31.5, 51.8)	52.2 (41.1, 63.1)
Wealthiest (Q5)	56.5 (51.2, 61.7)	51.3 (44.6, 57.8)	61.7 (51.9, 70.6)
Marital Status			
Currently married	44.9 (40.7, 49.2)	41.4 (36.3, 46.8)	54.0 (48.2, 59.7)
Others*	57.8 (53.6, 61.9)	57.8 (48.6, 66.4)	57.8 (53.2, 62.3)
Religion			
Muslim	48.5 (44.0, 53.0)	41.7 (36.0, 47.6)	56.1 (51.3, 60.8)
Others**	51.6 (47.4, 55.8)	46.0 (39.0, 53.2)	57.3 (52.5, 62.1)
Physical Activity			
>=150 Minutes/week	44.6 (40.9, 48.3)	36.5 (31.3, 42.0)	53.8 (49.6, 57.9)
<150 Minutes/week	56.2 (51.0, 61.2)	52.3 (45.6, 59.0)	60.1 (53.9, 66.1)
Fruits & Vegetables Consumption			
>=5 servings/day	44.7 (36.6, 53.0)	37.0 (27.4, 47.7)	62.6 (50.9, 73.0)
<5 servings/day	49.5 (45.5, 53.4)	43.2 (38.2, 48.3)	55.9 (51.4, 60.3)
Body Mass Index			
Normal	46.5 (42.2,50.8)	38.5 (33.5,43.9)	56.3 (50.7,61.8)
Underweight	32.9 (27.3,39.0)	30.0 (22.3,39.1)	36.6 (29.9,43.8)
Overweight	64.2 (58.9,69.1)	60.2 (54.4,65.7)	68.0 (59.5,75.4)
Obese	74.8 (64.3,83.0)	72.5 (57.7,83.6)	76.4 (62.6,86.3)

Waist Circumference			
Male: <90 cm/ Female: <80 cm	41.7 (37.3,46.1)	36.6 (31.4,42.1)	48.9 (43.4,54.4)
Male: >= 90 cm/ Female: >=80 cm	67.8 (63.7,71.6)	65.4 (58.4,71.8)	69.2 (63.0,74.7)
Self-reported diabetes			
No	47.5 (43.8, 51.1)	40.9 (36.0, 46.0)	54.9 (51.1, 58.7)
Yes	64.9 (55.2, 73.5)	60.5 (49.6, 70.5)	68.5 (56.2, 78.7)

¥Test was done between hypertension (Yes vs. No) and sex (Male vs. Female) for categories of the variables;
*Never married, widows, divorced and separated
**Hindu, Christian, Buddhist and others

Table 3: Factors associated with hypertension among elderly Bangladeshi people stratified by sex

Variables	Male				Female			
	COR	95% CI	AOR	95% CI	COR	95% CI	AOR	95% CI
Age (in Years)								
60 to 69	Ref		Ref		Ref		Ref	
70+	1.42***	1.19, 1.68	1.37**	1.13, 1.66	1.39***	1.17, 1.66	1.40**	1.15, 1.70
Place of Residence								
Rural	Ref		Ref		Ref		Ref	
Non-slum urban	1.72***	1.38, 2.15	0.94	0.70, 1.24	1.87***	1.48, 2.37)	1.19	0.88, 1.60
Slum	0.76	0.58, 1.00	0.68*	0.50, 0.92	0.88	0.69, 1.13	0.88	0.67, 1.16
Educational status								
No education	Ref		Ref		Ref		Ref	
Up to 5th grade	1.07	0.84, 1.37	0.93	0.72, 1.21	1.00	0.75, 1.33	0.96	0.71, 1.30
Up to 10th grade	1.62***	1.32, 1.98	1.28*	1.03, 1.60	1.71***	1.30, 2.25	1.29	0.96, 1.74
Above 10th grade	3.12***	2.44, 3.99	1.98***	1.49, 2.63	3.79**	1.68, 8.57	2.50*	1.01, 6.21
Wealth Quintile								
Least wealthy	Ref		Ref		Ref		Ref	
Lower	0.95	0.74, 1.23	0.96	0.74, 1.25	1.28	0.98, 1.66	1.26	0.95, 1.65
Middle	1.37*	1.07, 1.75	1.20	0.92, 1.56	1.41*	1.08, 1.84	1.33*	1.01, 1.77
Upper	1.23	0.96, 1.57	0.96	0.73, 1.27	1.19	0.91, 1.55	0.95	0.71, 1.26
Wealthiest	1.75***	1.36, 2.25	0.97	0.72, 1.32	1.66***	1.27, 2.16	1.06	0.77, 1.46
Marital Status								
Currently married	Ref		Ref		Ref		Ref	
Others£	1.37*	1.03, 1.82	1.16	0.85, 1.60	1.23*	1.02, 1.49	1.04	0.85, 1.29
Religion								
Muslim	Ref		Ref		Ref			
Others££	1.28*	1.03, 1.60	1.17	0.92, 1.48	0.99	0.79, 1.24	NA	NA
Physical Activity								
≥150 minutes/week	Ref		Ref		Ref		Ref	
<150 minutes/week	1.95***	1.66, 2.29	1.53***	1.27, 1.83	1.72***	1.45, 2.03	1.40***	1.17, 1.69
Fruits & Vegetables								
≥5 servings/day	Ref		Ref		Ref			

<5 servings/day	1.35*	1.06, 1.72	1.26	0.97, 1.63	0.98	0.68, 1.40	NA	NA
Body Mass Index (BMI)								
Normal	Ref		Ref		Ref		Ref	
Underweight	0.62***	0.50, 0.77	NA	NA	0.56***	0.45, 0.69	NA	NA
Overweight	2.25***	1.83, 2.77	NA	NA	1.69***	1.35, 2.12	NA	NA
Obese	4.53***	2.96, 6.93	NA	NA	2.99***	2.10, 4.25	NA	NA
Waist Circumference								
Male: <90 cm/ Female: <80 cm	Ref		Ref		Ref		Ref	
Male: >= 90 cm/ Female: >=80 cm	3.39***	2.78, 4.14	2.81***	2.26, 3.49	2.46***	2.06, 2.94	2.21***	1.82, 2.67
Self-reported Diabetes								
No	Ref		Ref		Ref		Ref	
Yes	2.22***	1.72, 2.88	1.40*	1.05, 1.87	2.45***	1.85, 3.23	1.83***	1.36, 2.46

* p < 0.05, ** p < 0.01, *** p < 0.001; CI: Confidence Interval; COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio; NA: Not applicable, these variables were not included in the adjusted analysis as these were dropped either due to the significance level was >0.2 in the crude analysis or due to high correlation with a covariate.

£Never married, widows, divorced and separated
££Hindu, Christian, Buddhist and others

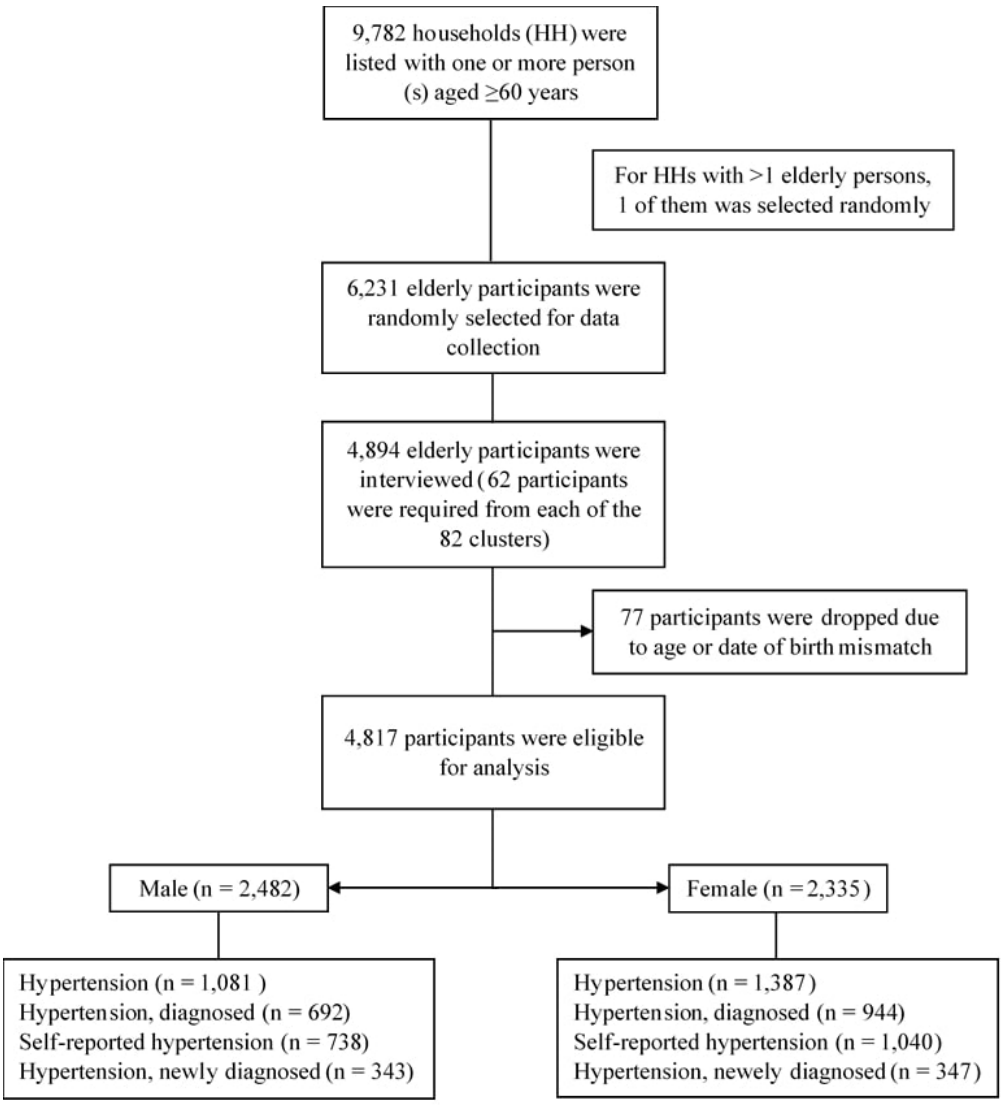

Figure 1: Study flow chart of participants selection (aged ≥60 years)

65x71mm (300 x 300 DPI)

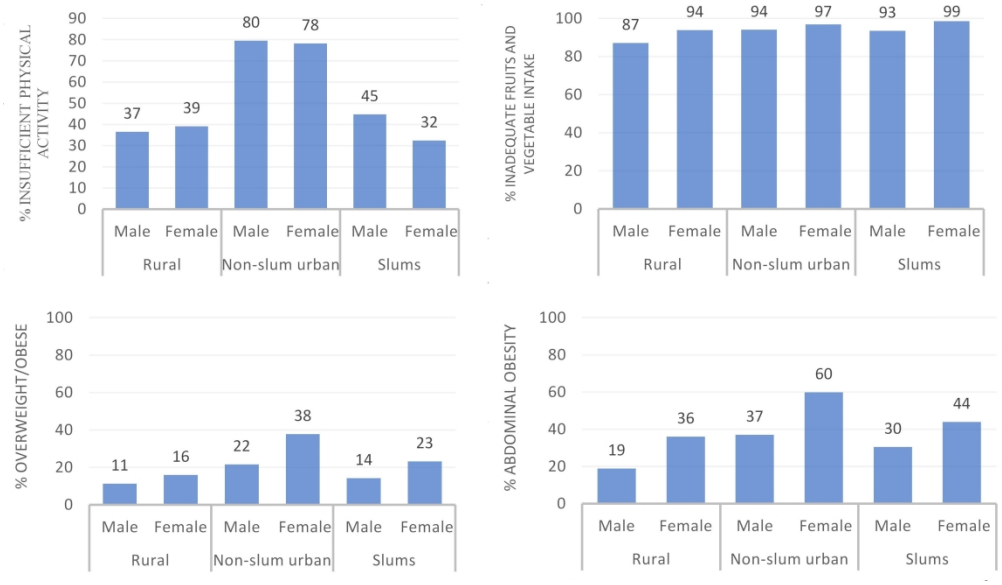

Figure 2: Selected behavioral and clinical characteristics by area of residence and gender

Supplementary table 1: Factors associated with hypertension among elderly Bangladeshi people stratified by sex (adjusted for body mass index instead of waist circumference)

Variables	Male				Female			
	COR	95% CI	AOR	95% CI	COR	95% CI	AOR	95% CI
Age (in Years)								
60 to 69	Ref		Ref		Ref		Ref	
70+	1.42***	1.19, 1.68	1.49***	1.22, 1.81	1.39***	1.17, 1.66	1.52***	1.24, 1.87
Place of Residence								
Rural	Ref		Ref		Ref		Ref	
Non-slum urban	1.72***	1.38, 2.15	0.91	0.68, 1.21	1.87***	1.48, 2.37)	1.10	0.81, 1.50
Slum	0.76	0.58, 1.00	0.66**	0.48, 0.89	0.88	0.69, 1.13	0.88	0.66, 1.16
Educational status								
No education	Ref		Ref		Ref		Ref	
Up to 5th grade	1.07	0.84, 1.37	0.95	0.73, 1.24	1.00	0.75, 1.33	0.98	0.72, 1.34
Up to 10th grade	1.62***	1.32, 1.98	1.25	1.00, 1.56	1.71***	1.30, 2.25	1.29	0.95, 1.75
Above 10th grade	3.12***	2.44, 3.99	1.87***	1.40, 2.48	3.79**	1.68, 8.57	2.46	0.99, 6.14
Wealth Quintile								
Least wealthy	Ref		Ref		Ref		Ref	
Lower	0.95	0.74, 1.23	0.95	0.72, 1.24	1.28	0.98, 1.66	1.30	0.98, 1.72
Middle	1.37*	1.07, 1.75	1.18	0.90, 1.54	1.41*	1.08, 1.84	1.36*	1.02, 1.81
Upper	1.23	0.96, 1.57	0.95	0.72, 1.25	1.19	0.91, 1.55	0.92	0.68, 1.24
Wealthiest	1.75***	1.36, 2.25	0.97	0.71, 1.32	1.66***	1.27, 2.16	1.05	0.76, 1.45
Marital Status								
Currently married	Ref		Ref		Ref		Ref	
Others[£]	1.37*	1.03, 1.82	1.15	0.83, 1.59	1.23*	1.02, 1.49	1.06	0.86, 1.32
Religion								
Muslim	Ref		Ref		Ref			
Others[£££]	1.28	1.03, 1.60	1.13	0.89, 1.44	0.99	0.79, 1.24	NA	NA
Physical Activity								
≥150 minutes/week	Ref		Ref		Ref		Ref	
<150 minutes/week	1.95***	1.66, 2.29	1.51***	1.25, 1.81	1.72***	1.45, 2.03	1.40**	1.16, 1.69
Fruits & Vegetables								
≥5 servings/day	Ref		Ref		Ref			
<5 servings/day	1.35*	1.06, 1.72	1.24	0.96, 1.62	0.98	0.68, 1.40	NA	NA
Body Mass Index (BMI)								
Normal	Ref		Ref		Ref		Ref	
Underweight	0.62***	0.50, 0.77	0.61***	0.48, 0.76	0.56***	0.45, 0.69	0.53***	0.42, 0.66
Overweight	2.25***	1.83, 2.77	1.97***	1.58, 2.46	1.69***	1.35, 2.12	1.60***	1.27, 2.02
Obese	4.53***	2.96, 6.93	3.76***	2.41, 5.87	2.99***	2.10, 4.25	2.54***	1.76, 3.69
Waist Circumference								

Males <102 cm; Females <88 cm	Ref		Ref		Ref		Ref	
Males ≥102 cm; Females ≥88 cm	3.39***	2.78, 4.14	NA	NA	2.46***	2.06, 2.94	$	$
Self-reported Diabetes								
No	Ref		Ref		Ref		Ref	
Yes	2.22***	1.72, 2.88	1.34	1.00, 1.79	2.45***	1.85, 3.23	1.74***	1.29, 2.35

* p < 0.05, ** p < 0.01, *** p < 0.001; CI: Confidence Interval; COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio;

NA: Not applicable, these variables were not included in the adjusted analysis as these were dropped due to the significance level was >0.2 in the crude analysis

$: Although waist circumference was used in the final model, BMI is used here to produce a supplementary table to show to results of the analysis using BMI instead of waist circumference.

[£]Never married, widow/widower, divorced and separated

[ff]Hindu, Buddhist, Christian and others

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	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3-4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4-5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	*6-7*
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable
		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*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	5
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	5
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-8
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	7-8
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	7-9
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*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	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-9
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	12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-12
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	16

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

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

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Gender-specific prevalence and associated factors of hypertension among elderly Bangladeshi people: findings from a nationally representative cross-sectional survey

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Gender-specific prevalence and associated factors of hypertension among elderly Bangladeshi people: findings from a nationally representative cross-sectional survey

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Abstract

Objective: We aimed to estimate the gender-specific prevalence and associated factors of hypertension among elderly people in Bangladesh.

Design and method: We analyzed data from the food security and nutrition surveillance round 2018-19. The multistage cluster sampling method was used to select the study population. Hypertension was defined as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg and/or having a history of hypertension. We carried out the descriptive analysis, bivariate and multivariable logistic regression to report the weighted prevalence of hypertension as well as crude and adjusted odds ratios with 95% confidence interval. A p-value <0.05 was considered statistically significant.

Setting: The study was conducted in 82 clusters (57 rural, 15 non-slum urban, and 10 slums) in all 8 administrative divisions of Bangladesh.

Participants: A total of 2,482 males and 2,335 females aged ≥60 years were included in the analysis.

Results: The weighted prevalence of hypertension was 42% and 56% among males and females, respectively. The prevalence was higher among females across all sociodemographic, behavioural, and

biological strata. Factors associated with higher odds of hypertension [AOR (95%CI)] in both genders were age 70+ years [1.32 (1.09,1.60) for males and 1.40 (1.15,1.71) for females]; insufficient physical activity [1.50 (1.25,1.81) and 1.38 (1.15,1.67)]; higher waist circumference [2.76 (2.22,3.43) and 2.20 (1.82,2.67)]; and self-reported diabetes [1.36 (1.02,1.82) and 1.82 (1.35,2.45)]. Additionally, living in slums decreased [0.71(0.52,0.96)] and education >10 years increased odds of hypertension [1.83 (1.38,2.44)] among males.

Conclusion: In Bangladesh, half of the elderly were hypertensive, with a higher prevalence in females. Odds of hypertension was increased by older age (≥70 years), education >10 years, insufficient physical activity, abdominal obesity, and self-reported diabetes. The Ministry of Health of Bangladesh should consider this while designing and implementing health programs.

Keywords: Hypertension, elderly people, prevalence, Bangladesh

Strengths and limitations of this study

- Information on the prevalence, gender-difference, and associated factors of hypertension among the elderly Bangladeshi population are scarce.
- The nationally representative design allowed the objective assessment of the prevalence, gender-difference, and factors of hypertension among the elderly Bangladeshi population.
- Blood pressure was measured on a single day rather than longitudinal measurements to confirm the diagnosis of hypertension.
- The associations might not be causal due to lack of temporality, as the study was a cross-sectional one.
- Some strong confounders such as salt consumption, genetic factors could not be addressed.

Introduction

The proportion of the ageing population around the world is rapidly increasing, and the pace is faster than ever. The global population aged ≥60 years reached 962 million in 2017, more than double compared to 1980 and is projected to double again by 2050 when it reaches 2.1 billion [1]. In another estimate, globally, the population aged ≥60 years will be 22% by the year 2050, and 80% of which will live in low and middle-income countries [2]. In 2017, 8.8% of the South Asian population was aged ≥60

years, which is projected to be 18.9% by 2050 [1]. Despite its arbitrary nature, persons aged ≥65 years are considered as elderly in most of the developed countries [3]. However, in Bangladesh, persons aged ≥60 years are considered as elderly people considering the shorter longevity [4]. Bangladesh witnessed a five-fold increase in the elderly population between 1974 and 2001 [5]. According to the Bangladesh Bureau of Statistics, about 12.5 million (7.5%) of Bangladeshi people were elderly in 2019, which is expected to be 40 million (20%) by the year 2050 [6].

Hypertension or raised blood pressure is a condition when the pressure of blood flow on the vessel walls become higher than normal [7]. People often are not aware of whether they are hypertensive or not, and hence it is often called the "silent killer" [8]. Globally, hypertension is one of the major causes of deaths and disabilities. According to the World Health Organization Global Health Observatory (GHO) 2016 data, 7.5 million annual deaths were estimated to be caused by high blood pressure, which was about 12.8% of total deaths worldwide. Hypertension is also accounted for 57 million disability-adjusted life years (DALYs), which amounts to 3.7% of total DALYs [9]. Globally, hypertension is responsible for 45% of deaths from cardiac causes, and 51% of the deaths from stroke [10]. As a risk factor, hypertension causes nearly 30% of all cardiovascular disease [11].

The prevalence of hypertension substantially increases with age. Evidence from the Framingham heart study, the longest-standing study on cardiovascular disease epidemiology, showed that more than 90% of the people who remain normotensive (systolic blood pressure <120 mmHg and diastolic blood pressure < 80 mmHg) at the age of 65 years would develop hypertension (systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥90 mmHg) at their remaining life-span, may be due to age-related vascular changes [12]. Kibria et al. analyzed data from the Bangladesh Demographic and Health Survey 2011 (BDHS 2011) and reported that 30% of the males and 52% of the females aged ≥65 years were hypertensive, along with 25% of both genders of the same age group were prehypertensive (SBP 120-139 mmHg; DBP 80-89 mmHg)[13]. Another study reported that an estimated 23% of the elderly people in rural Bangladesh had undiagnosed hypertension (those who had no known hypertension but found hypertensive upon measurement), and among those who were diagnosed and were receiving treatment, 68% had uncontrolled hypertension (blood pressure above the normal range despite antihypertensive treatment) [14].

Despite these facts, hypertension among elderly people in this region could not gain enough attention. One of the reasons can be limited information due to poor or no screening and control measures for hypertension among the elderly population. To the best of our knowledge, there is no study reporting national prevalence and associated risk factors of hypertension among the elderly Bangladeshi population of 60 years and above. Even some studies have excluded older adults who are at higher risk

of NCDs. Accordingly, the objective of our study is to report the prevalence and factors associated with hypertension among elderly males and females of Bangladesh.

Materials and Methods

Study design and site

We conducted a cross-sectional survey among six population groups (children <5 years, adolescent boys, adolescent girls, adult females, adult males, and elderly people). Our objective was to generate nationally and divisionally representative estimates of different nutrition and health-related variables, including major non-communicable diseases in elderly males and females. The data collection period was from October 2018 through October 2019. In this nationally representative study, we enrolled participants from all eight administrative divisions (Barisal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, and Sylhet). We covered rural, non-slum urban and slum areas. We enrolled in study subjects from 82 randomly selected clusters (57 rural, 15 non-slums urban, and 10 slums).

Sample size and sampling techniques

We determined the sample size to generate nationally, and divisionally representative prevalence for the selected indicators with prevalence ranged from 4% to 98% using a multistage cluster sampling. We considered the type I error, $\alpha = 0.05$; allowable margin of error, $d = 0.05$ (or d = prevalence/2 if prevalence ≤ 0.1); design effect, DEF = 1.61 and calculated a sample size of 62 elderly individuals from each cluster. Accordingly, the sample size for the elderly population was 5,580 from 90 clusters in the country. Finally, we could complete collecting data from 82 clusters and obtained a sample size of 4,894 elderly people.

Different sampling designs were applied to select the study sites in rural, urban, and slum areas. For the rural area, two districts were first selected from each division in the first stage of four-stage sampling. From each district, two sub-districts (Upazilla) were randomly selected. In the third stage, two unions were randomly chosen from each of the selected sub-districts. The villages/mouzas/geographically demarcated segments with 250-400 households were then identified and mapped. Finally, we randomly selected two of the listed village/mouza/segments from each union as study clusters.

In the urban areas, we used the population proportion of Bangladesh Bureau of Statistics (BBS) 2011 census [15]. We randomly selected 16 wards (1-2 wards/division). We then identified the Mahalla (similar to the villages) with more than 250 households, and the mahallas with >500 households were further sub-divided into smaller geographically demarcated segments of ~250 households. We randomly picked one segment from the listed segments from the selected wards, and that was our study cluster.

In the slum areas, the Census of Slum Areas and Floating Population 2014 was used for the selection of study sites [16]. Slums having ≥ 300 households were identified, and those with >500 households were further divided into smaller segments. Two segments from the Dhaka and Chattogram divisions and one from each of the other six divisions were randomly selected as study clusters.

For each cluster, data collectors first listed all households with individuals aged ≥60 years. A statistician then selected 80 households from the list using Simple Random Sampling to enrol 62 elderly people from a cluster. After selecting the households from a cluster, if there was any household with more than one person aged ≥60 years, we randomly selected one of them using the simple random sampling method. Figure 1 demonstrates how the participants were selected in the study.

Figure 1: Study flow chart of participants selection (aged ≥60 years)

Data Collection

We collected data using a structured questionnaire, developed initially in English, and then translated into the local language. Data were collected using face to face interviews and physical measurements and were directly entered in tablet computers (Samsung Galaxy Tab A7) using a customized SurveyCTO application [17]. At the end of everyday data collection, data collectors uploaded all the collected data to the server. We measured the height (using locally made portable stadiometer), weight (using TANITA UM-070 weighing scale), waist circumference (using measuring tape), and blood pressure (using Omron HEM 7120) of the elderly people.

To collect data on self-reported hypertension, the data collector(s) asked the participant the following question - "Has a health care provider ever told you that you have high blood pressure, also called hypertension (other than during pregnancy)?" Before measuring blood pressure, the data collector ensured that the participant was in a resting condition for at least 15 minutes. There was a three minutes interval between two subsequent measurements. If there was a gap of ≥10 mmHg between the first two measurements of either systolic or diastolic blood pressure or both, a third measurement was taken.

Anthropometric measurements were taken based on WHO guidelines, as specified in the Food and Nutrition Technical Assistance (FANTA) anthropometry manual [18]. The weight was measured to the nearest 0.1 kg with light cloths, and height was measured to the nearest 0.1 cm in the standing position with no shoes. Waist circumference was measured to the nearest 0.1 cm at the end of a normal

expiration, at the midpoint between the lower part of the last rib and the top of the hipbone, with the arms relaxed at the sides. Usually, we took two measurements of weight, height, and waist circumference, and if the gap between the two first measurements were >0.1 kg for weight and >0.5 cm for height and waist circumference, we took the third measurement.

Operational definitions

The outcome variable in our analysis was the hypertension status of elderly males and females. Hypertension was defined as systolic blood pressure ≥140 mmHg, or diastolic blood pressure ≥90 mmHg or if the participants were told as hypertensive by any trained health care provider (self-reported) [19]. The variable was made dichotomous either as hypertensive (measured or self-reported) or as non-hypertensive to facilitate logistic regression.

We made a list of potential factors associated with hypertension among elderly people based on literature review and types of data collected by the survey. The socioeconomic factors were age (60-69 years vs 70+ years), place of residence (rural, non-slum urban, and slum), education (no formal education, up to primary level, up to 10 completed years and >10 completed years), wealth status, marital status (currently married vs never married, divorced, widowed or separated), and religion (Muslim vs others).

The behavioural factors were physical activity, fruits, and vegetable consumption (≥5 servings/day vs <5 servings). An elderly person was considered doing sufficient physical activity (during work, transport, and recreational activities), if he or she reported at least 150 minutes of moderate-intensity physical activity per week or 75 minutes of heavy physical activity per week or equivalent [20].

Body mass index, waist circumference, and self-reported diabetes were the anthropometric and clinical factors. We used the Asian cutoff to categorize Body Mass Index (BMI) into underweight (<18.5 kg/m2), normal (≥18.5 to <23.0 kg/m2), overweight (≥23.0 to <27.5 kg/m2, and obese (≥27.5 kg/m2) [21]. Abdominal obesity was defined as the waist circumference of ≥90 cm in males and ≥80 cm in females [22]. For this analysis, we considered the average of the two closest measurements for blood pressure and all anthropometric variables. Self-reported diabetes was documented if any participant reported that a trained health care provider ever told him or her that he or she had diabetes.

Quality Assurance and Control

Data collectors and the field supervisors received extensive training on interviews, anthropometric measurements, and maintenance of data collection instruments and had gone through a rigorous

standardization procedure. We field-tested the questionnaire, modified it, and refreshed the data collectors based on the findings of field testing. To ensure data quality, the field supervisors directly observed 5% of the interviews and re-interviewed another 5% of the randomly selected participants within 48 hours of the initial visit. Interim analyses were performed to check the data quality. All the measuring tools were calibrated routinely.

Statistical Analysis

We performed all the data analysis using Stata 15.1 (Stata Corp, College Station, TX, USA) [23]. All the background characteristics are reported as categorical variables. We performed principal component analysis (PCA) to calculate wealth quintiles of the households of the participants. We estimated the weighted prevalence of hypertension for both elderly males and females. As the males and females differed by the distribution of risk factors and the prevalence of hypertension, we conducted separate bivariate and multivariable logistic regression, respectively, to identify the factors associated with hypertension. The variables with a p-value of ≤0.2 in the crude analysis were included in the multivariable logistic regression model a[24]. Variance inflation factors (VIFs) were also checked to assess multi-collinearity among variables. Age, BMI and waist circumference were continuous variables, and none of them was normally distributed. We converted the continuous variables into categorical variables and included in the analysis. However, we ran separate regression models including the age, BMI and waist circumference as continuous variables and provided the results in **Supplementary Table 1.** We included both BMI and waist circumference separately in our initial analysis as both are important predictors of hypertension. Finally, we used the waist circumference in the regression model due to its high correlation with BMI ($r = 0.87$, $P < 0.001$) as well as its program implications as waist circumference can be easily measured and interpreted for screening in a low resource setting. We also ran the separate multivariable logistic regression models, including BMI as an independent variable and provided the results in **Supplementary Table 2.** Crude and adjusted odds ratios were estimated at 95% Confidence Intervals and the determinants with the p-value <0.05 were considered statistically significant.

Ethical considerations

The FSNSP 2018-19 obtained the ethical approval from the Institutional Review Board (IRB) of the BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh (IRB Reference number: 2018-020-IR). Written informed consent was taken from the respondents before data collection and measurements.

Results

Table 1 describes the characteristics of the study participants. The median (interquartile range) age of the participants was 65.8 (62.4, 71.8) years. The female participants were Of 48.4%, and the rural area contributed 72.0% of the study subjects. More females (77.1%) were identified without any formal education compared to their male counterparts (48.9%). Only one in every four females and 92% of the males were found married at the time of the survey. Above one-third of the participants from both genders (42% of males and 45% of females) reported insufficient physical activity. Daily fruits and vegetable consumption of 9 out of 10 elderlies were <5 servings. About 37% of males and 3% of females reported themselves as current smokers, whereas about 41% of elderly males and 58% of elderly females reported themselves as a current user of smokeless tobacco. A higher proportion (34.4%) of females were overweight or obese than males (28.0%). Abdominal obesity was identified among 23% of males and 41% of females. About 11% of elderly males and 13% of elderly females reported having diabetes.

Table 1: Background characteristics of the study population by hypertension (no/yes) and gender (male/female)

Figure 2 demonstrates the distribution of a few selected behavioural and clinical characteristics across the places of residence and genders. In our study, the prevalence of these risk factors is higher among elderly females compared to their male counterparts except for insufficient physical activity in urban areas. Almost 80% of males and 78% of females of the non-slum urban area reported performing an insufficient physical activity, which is around 40% in both rural and slum areas. Overall, 91% of the elderly were consuming inadequate fruits and vegetables, which was 94% in females and 87% in males. However, above 98% of slum women failed to consume the recommended servings of fruits and vegetables. Overweight/obesity was also highest in urban females, which was about 38% compared to 22% in urban males. Similarly, 60% of urban females were identified with abdominal obesity.

Figure 2: Selected behavioural and clinical characteristics by area of residence and gender

Table 2 shows the prevalence of hypertension according to the characteristics of the participants and how it differs between males and females. In total, more females (56%) were identified as hypertensive than males (42%). Urban elderly females had the highest prevalence of hypertension (63%), whereas the male slum dwellers had the lowest (30%). The wealthiest of the population had the highest prevalence of hypertension in both genders (51% in males and 62% in females). Married elderly males had a lower prevalence of hypertension (41%) compared to those who were not married during the survey (58%). The prevalence of hypertension increased with age, education, body mass index, and waist circumference in both genders. However, the prevalence of hypertension was lower among those who reported sufficient physical activity, and adequate consumption of fruits and vegetables. In contrast, the prevalence of hypertension was found lower among current smokers (35% vs 52%). However, the prevalence of hypertension did not differ much between current users and non-users of smokeless tobacco in this survey.

Table 2: Prevalence of hypertension according to background characteristics among elderly males and females (weighted) with 95% Confidence Interval (CI)¥

We reported the results of bivariate and multivariable logistic regressions in **Table 3**. In bivariate analysis, we found that all the selected variables were significantly associated with hypertension in males, whereas in females, we found that age, place of residence, education, wealth index, marital status, physical activity, BMI, waist circumference and diabetes were significantly associated with hypertension. However, in multivariable logistic regression analysis, we found that age ≥70 years [AOR with 95%CI: 1.32 (1.09,1.60) for males and 1.40 (1.15,1.71) for females] compared to 60-69 years; insufficient physical activity [AOR with 95%CI: 1.50 (1.25,1.81) and 1.38 (1.15,1.67)] compared to the recommended amount of physical activity; abdominal obesity [AOR with 95%CI: 2.76 (2.22,3.43) and 2.20 (1.82,2.67)] with reference to no abdominal obesity, i.e. normal waist circumference (Male: <90 cm/ Female: <80 cm); and self-reported diabetes [AOR with 95%CI: 1.36 (1.02,1.82) and 1.82 (1.35,2.45)] compared to no reported diabetes was associated with increased odds of hypertension among both elderly males and females. Additionally, living in slums decreased odds of hypertension [AOR with 95%CI: 0.71 (0.52,0.96)] compared to rural residents and education above 10th grade increased odds of hypertension [AOR with 95%CI: 1.83 (1.38,2.44)] compared to no formal education among males. Surprisingly, the elderly males who were reportedly smoker or smokeless tobacco user during data collection were found having decreased odds of hypertension in bivariate logistic regression. The similar effects of smoking persisted even after adjusting with potential confounders in multivariable logistic regression, where, being a current smoker was associated with increased odds of hypertension among elderly males [AOR with 95%CI: 0.74 (0.61,0.89)] compared to those who were currently non-smoker.

Table 3: Factors associated with hypertension among elderly Bangladeshi people stratified by gender

Discussion

In our study, the overall prevalence of hypertension among the elderly people of Bangladesh was 49%, which is similar to the weighted pooled prevalence of hypertension (53%) in Bangladeshi population aged ≥60 years reported in a 2020 systematic review and meta-analysis [25]. The estimated prevalence is also very close to the south Asian prevalence of hypertension among elderlies aged ≥65 years (53%) but lower than the average prevalence in the low and middle-income countries (66%) reported in a recent systematic review and meta-analysis [26]. The prevalence is still lower than the prevalence of hypertension in high-income countries. In a systematic analysis, Katherine et al. demonstrated that, in 2010, the prevalence of hypertension among the high-income countries was 60.8% (male: 55.3%; female: 60.9%) and 73.6% (male: 65.6%; female: 77.5%) in the age groups 60-69 years and 70+ years, respectively [27]. However, our reported prevalence is higher than the prevalence previously estimated in Bangladesh demographic and health survey 2011, which was 35% and 40% for the age groups 60-69 and 70+ years, respectively [28]. The increase in the prevalence of hypertension may be due to recent advancements in the economy and infrastructure of the country, leading the people into sedentary lifestyles and stress [29-31]. Hypertension is considered as the most important modifiable risk factor of cardiovascular diseases worldwide [32]. It has been shown that hypertension is responsible for nearly 30% of all cardiovascular diseases, and a person with hypertension has nearly three times the likelihood of having cardiovascular incidents compared to non-hypertensive individuals [11]. As a major contributor to cardiovascular diseases, hypertension causes a major proportion of ischemic heart diseases, heart failure, renal failure, as well as cerebrovascular diseases such as stroke [33]. As almost half of the population in the elderly age group in Bangladesh is hypertensive, we can indisputably assert that Bangladesh must take immediate steps to address this problem. Policymakers need to pay special attention while designing the screening and intervention program considering the health and wellbeing of the elderly people.

After segregating by gender, the prevalence of hypertension was 42% and 56% for males, and females, respectively. This higher prevalence among females is supported by several studies in Bangladesh and elsewhere [34]. It may be due to a lack of ovarian hormones during the postmenopausal period. Studies suggested that ovarian hormones, especially estrogen, may have the potentials to keep the blood pressure lower in premenopausal women, and lack of it may be responsible for elevated blood pressure

in postmenopausal women [35]. Moreover, our findings indicate that women, at their advanced age, become socially more vulnerable to hypertension. For example, three out of four elderly women did not have a spouse, and it may affect their health care seeking and treatment. The government should pay additional attention to design customized screening and awareness programs for elderly people with particular attention to the vulnerability of women.

Our study corroborated the fact that the odds of developing hypertension increases with age in both genders. Studies conducted in Bangladesh [13], India [36], Pakistan [37], Nepal [38], Indonesia [39], and China [40], have shown that the older age group had a higher prevalence of hypertension. The biological effect of the increased arterial resistance due to age-related changes in the arterial wall, i.e., thickening of the arterial wall in old ages, may contribute to high-risk of hypertension in older ages [41]. Bangladesh is in the midst of a huge demographic transition, and with the decreasing trend of birth and death rate, the proportion of the elderly population is growing, which will eventually add more hypertensive patients and create more pressure on the already over-burdened health system of the country. In this study, insufficient physical activity increased the odds of having hypertension in both genders. Elderlies, who reported less than 150 minutes of moderate-intensity or equivalent physical activity per week, had around 1.5 times more odds of having hypertension compared to those with 150 minutes or more such physical activity. This finding is supported by numerous studies [13 38 42]. Besides, physical inactivity was also found associated directly with stroke and ischemic heart diseases [43]. Elderly males and females with higher waist circumference had three times and two times more odds of having hypertension, respectively, with refer to those with lower or normal waist circumference. Several studies have reported that waist circumference, as it represents abdominal obesity, is a better predictor of hypertension compared to BMI [44 45].

In this study, smoking use was found inversely associated with hypertension for both males and females. These findings are contrary to the existing evidence that smoking causes adverse cardiovascular events and increases the risk of coronary heart diseases in a combined role with hypertension and dyslipidemia [46]. This finding may be due to the reverse causation because the participants might have given up the habit of smoking due to known hypertension status, and we collected the data only on current smoking status. At least one study suggested that to see the proper effects of smoking on hypertension, smoking data should be collected in a life-course approach as the effects of smoking may not appear immediately after starting or quitting smoking [47]. In our analysis, fruits and vegetable consumption was not found significantly associated with hypertension in both genders. In the case of hypertension, fruit and vegetable consumption usually helps with increased potassium intake. But in Bangladesh, improper processing, such as washing after cutting or over-cooking, may reduce the amount of potassium [48 49]. Also, not all fruits and vegetables have a high level of potassium. However, this should be studied further to explore the causal pathway between

hypertension and fruits & vegetables.

Among other factors, a higher level of education was responsible for the increased odds of having hypertension. Elderly males and females with more than ten years of education had about two times higher odds of having hypertension compared to those without any formal education. Kibria et al. found similar results analyzing the data from the Bangladesh Demographic and Health Survey 2011 [13]. Education levels may elevate wealth status, which makes the people used to a sedentary lifestyle, and eventually may increase the odds of hypertension [50]. However, the wealth index did not show any such clear pattern, although elderlies in the upper wealth quintiles had a relatively higher prevalence of hypertension [Table 2]. In this study, living in slums was associated with lower odds of hypertension though it was not statistically significant in the case of the females. Self-reported diabetes was also increased odds of having hypertension in both males and females in this age group of the population, which is supported by several studies in Bangladesh and elsewhere [51-53].

Recommendations

Risk factors such as insufficient physical activity and obesity are mostly modifiable by appropriate education and control programs with support from the health and other sectors of the government. The early diagnosis of hypertension and other health problems is critical for controlling hypertension and the prevention of hypertension-related complications. However, the gender difference in the prevalence of and factors associated with hypertension indicated that a universal prevention and control strategy might not work in this age group of population. Instead, the government should design a specific screening and control program to reduce the number of cases by early diagnosis and control and eventually minimize further complications of hypertension. Besides, education programs should immediately be initiated to raise awareness among the elderly males and females as well as their family members on healthy lifestyles. The introduction of geriatric health care with the general health care system at the primary health care level can be a crucial step in improving the overall health of elderly people.

Strengths and limitations

Prevalence of hypertension among elderly people was reported in several studies in Bangladesh. However, to the best of our knowledge, this is the first-ever nationally representative survey in Bangladesh investigating the prevalence and associated factors of hypertension among the elderly people. The limitations of the study include sampling challenges at the field level. The data collectors faced higher refusal rates in wealthier non-slum urban areas and a few isolated rural communities.

Besides, seven selected rural clusters were dropped from the survey due to administrative and financial constraints, which may affect the national representativeness in the study. Among other limitations, blood pressure measurements were taken on a single day rather than longitudinal measurements on different days to confirm the diagnosis of hypertension. Also, the associations we have found in our study might not be causal due to lack of temporality, as the study was a cross-sectional one. Besides, we could not adjust for some strong confounders, such as salt consumption, genetic factors [54 55]. However, these limitations emphasize the importance of further research on the determinants of hypertension among the elderly people of Bangladesh. We also recommend studying the gender difference in the physiology and pathophysiology of hypertension by exploring the effects of gonadal hormones and gender chromosomes on blood pressure to yield customized management of hypertension separately for both males and females.

Conclusions

As per the findings of our study, about half of the Bangladeshi elderlies were hypertensive, and hypertension was more prevalent among elderly females in terms of sociodemographic, behavioural, and biological characteristics. Extreme old age (≥70 years), education above 10th grade, insufficient physical activity, abdominal obesity (higher waist circumference), and self-reported diabetes was associated with increased odds of hypertension in Bangladeshi elderly population. Additionally, living in slums had lower odds of hypertension among elderly males. The government of Bangladesh should take a multisectoral approach involving health, economic, education, and social welfare sectors to promote healthy lifestyles among the elderly people and their families and provide emphasis on early diagnosis and treatment to prevent complications of hypertension among the elderly population.

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Competing interests None declared.

Patient consent for publication Not applicable.

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Table 1: Background characteristics of the study population by hypertension (no/yes) and gender (male/female)

Variables	Overall	Hypertension		Gender	
		No	Yes	Male	Female
	N=4,813	N=2,345	N=2,468	N=2,482	N=2,335
	n(%)*	n(%)*	n(%)*	n(%)*	n(%)*
Gender					
Male	2,482 (51.6)	1,401 (59.7)	1,081 (43.8)	--	--
Female	2,331 (48.4)	944 (40.3)	1,387 (56.2)	--	--
Age (years)$	65.8 (62.4-71.8)	65.3 (62.1-70.8)	66.6 (62.8-73.3)	65.7 (62.6-71.4)	66.0 (62.3-72.9)
Age Group (in Years)					
60 to 69 years	3,223 (67.0)	1,668 (71.1)	1,555 (63.0)	1,725 (69.5)	1,500 (64.3)
70 years and above	1,589 (33.0)	677 (28.9)	912 (37.0)	757 (30.5)	834 (35.7)
Place of Residence					
Rural	3,463 (72.0)	1,757 (74.9)	1,706 (69.1)	1,835 (73.9)	1,628 (69.7)
Non-slum urban	806 (16.7)	292 (12.5)	514 (20.8)	394 (15.9)	413 (17.7)
Slum	544 (11.3)	296 (12.6)	248 (10.0)	253 (10.2)	294 (12.6)
Educational status					
No education	3,012 (62.6)	1,532 (65.3)	1,480 (60.0)	1,214 (48.9)	1,800 (77.1)
Up to 5th grade	556 (11.6)	302 (12.9)	254 (10.3)	342 (13.8)	216 (9.3)
Up to 10th grade	843 (17.5)	376 (16.0)	467 (18.9)	567 (22.8)	276 (11.8)
Above 10th grade	402 (8.4)	135 (5.8)	267 (10.8)	359 (14.5)	43 (1.8)
Wealth Quintile					

Least wealthy (Q1)	966 (20.1)	531 (22.7)	435 (17.6)	543 (21.9)	423 (18.1)
Lower (Q2)	968 (20.1)	500 (21.3)	468 (19.0)	485 (19.5)	484 (20.7)
Middle (Q3)	962 (20.0)	445 (19.0)	517 (20.9)	494 (19.9)	469 (20.1)
Upper (Q4)	957 (19.9)	475 (20.3)	482 (19.5)	491 (19.8)	467 (20.0)
Wealthiest (Q5)	959 (19.9)	393 (16.8)	566 (22.9)	469 (18.9)	491 (21.0)
Marital Status					
Currently married	2,860 (59.4)	1,558 (66.4)	1,302 (52.8)	2,277 (91.7)	584 (25.0)
Others**	1,953 (40.6)	787 (33.6)	1,166 (47.2)	205 (8.3)	1,751 (75.0)
Religion					
Muslim	4,073 (84.6)	2,005 (85.5)	2,068 (83.8)	2,113 (85.1)	1,962 (84.0)
Others***	740 (15.4)	340 (14.5)	400 (16.2)	369 (14.9)	373 (16.0)
Physical Activity					
>=150 Minutes/week	2,706 (56.2)	1,498 (63.9)	1,208 (48.9)	1,433 (57.7)	1,274 (54.6)
<150 Minutes/week	2,107 (43.8)	847 (36.1)	1,260 (51.1)	1,049 (42.3)	1,061 (45.4)
Fruits & Vegetables Consumption					
>=5 servings/day	450 (9.3)	253 (10.8)	197 (8.0)	320 (12.9)	130 (5.6)
<5 servings/day	4,363 (90.7)	2,092 (89.2)	2,271 (92.0)	2,162 (87.1)	2,205 (94.4)
Currently smoking					
No	3,828 (79.5)	1,708 (72.8)	2,116 (85.7)	1,564 (63.0)	2,264 (97.0)
Yes	989 (20.5)	637 (27.2)	352 (14.3)	918 (37.0)	71 (3.0)
Smokeless tobacco use					
No	2,438 (50.6)	1,146 (48.9)	1,290 (52.3)	1,455 (58.6)	983 (42.1)
Yes	2,379 (49.4)	1,199 (51.1)	1,178 (47.7)	1,027 (41.4)	1,352 (57.9)
Body Mass Index (BMI)$	20.9 (18.6-23.8)	19.9 (18.0-22.3)	22.1 (19.6-24.9)	20.7 (18.6-23.5)	21.2 (18.7-24.3)
BMI Category (Asian)					
Normal	2,077 (45.1)	1,098 (48.2)	979 (42.1)	1,145 (47.5)	932 (42.4)
Underweight	1,099 (23.9)	715 (31.4)	384 (16.5)	589 (24.4)	511 (23.2)
Overweight	1,084 (23.5)	390 (17.1)	694 (29.8)	554 (23.0)	530 (24.1)
Obese	345 (7.5)	76 (3.3)	269 (11.6)	121 (5.0)	226 (10.3)
Waist Circumference$	79.0 (71.4-87.9)	76.1 (69.6-83.9)	82.3 (74.1-91.2)	81.0 (73.3-89.1)	77.1 (69.1-86.4)
Waist Circumference					
Male: <90 cm/ Female: <80 cm	3,226 (68.5)	1,859 (80.4)	1,367 (57.0)	1,887 (77.1)	1,340 (59.1)
Male: >= 90 cm/ Female: >=80 cm	1,485 (31.5)	452 (19.6)	1,033 (43.0)	560 (22.9)	927 (40.9)
Self-reported diabetes					
No	4,234 (88.0)	2,167 (92.4)	2,067 (83.8)	2,212 (89.1)	2,026 (86.8)
Yes	579 (12.0)	178 (7.6)	401 (16.2)	270 (10.9)	309 (13.2)

* Column percentages
** Never married, widows, divorced and separated
*** Hindu, Christian, Buddhist and others
$ Median and Interquartile Range (IQR) calculated for the continuous variables

Table 2: Prevalence of hypertension according to background characteristics among elderly males and females (weighted) with 95% Confidence Interval (CI)¥

Variables	Overall	Male	Female
	% (95% CI)	% (95% CI)	% (95% CI)
Overall	49.0 (45.2, 52.9)	42.4 (37.4, 47.6)	56.3 (52.1, 60.4)
Age Group (in Years)			
60 to 69 years	47.6 (43.9, 51.4)	40.7 (35.3, 46.3)	55.2 (50.2, 60.0)
70 years and above	51.5 (45.4, 57.6)	45.5 (37.9, 53.3)	58.4 (52.9, 63.7)
Place of Residence			
Rural	49.0 (45.0, 52.9)	42.4 (37.3, 47.7)	56.2 (51.9, 60.5)
Non-slum urban	53.1 (48.4, 57.8	44.9 (38.5, 51.4)	62.9 (57.7, 67.8)
Slum	39.7 (32.4, 47.4)	29.7 (24.0, 36.1)	50.3 (40.9, 59.6)
Educational status			
No education	46.9 (42.6, 51.2)	34.4 (29.2, 40.0)	55.6 (51.0, 60.2)
Up to 5th grade	49.0 (40.3, 57.8)	44.1 (31.8, 57.2)	57.1 (47.4, 66.2)
Up to 10th grade	50.6 (45.0, 56.1)	47.4 (41.0, 53.8)	58.8 (47.3, 69.5)
Above 10th grade	66.8 (58.3, 74.3)	65.7 (56.8, 73.6)	81.2 (48.5, 95.2)
Wealth Quintile			
Least wealthy (Q1)	44.9 (38.8, 51.1)	39.3 (31.9, 47.1)	52.4 (43.5, 61.1)
Lower (Q2)	48.4 (43.8, 53.0)	39.0 (33.9, 44.3)	57.5 (51.4, 63.3)
Middle (Q3)	51.2 (45.3, 57.1)	45.1 (38.1, 52.2)	58.2 (50.4, 65.7)
Upper (Q4)	46.4 (38.0, 55.1)	41.2 (31.5, 51.8)	52.2 (41.1, 63.1)
Wealthiest (Q5)	56.5 (51.2, 61.7)	51.3 (44.6, 57.8)	61.7 (51.9, 70.6)
Marital Status			
Currently married	44.9 (40.7, 49.2)	41.4 (36.3, 46.8)	54.0 (48.2, 59.7)
Others*	57.8 (53.6, 61.9)	57.8 (48.6, 66.4)	57.8 (53.2, 62.3)
Religion			
Muslim	48.5 (44.0, 53.0)	41.7 (36.0, 47.6)	56.1 (51.3, 60.8)
Others**	51.6 (47.4, 55.8)	46.0 (39.0, 53.2)	57.3 (52.5, 62.1)
Physical Activity			
>=150 Minutes/week	44.6 (40.9, 48.3)	36.5 (31.3, 42.0)	53.8 (49.6, 57.9)
<150 Minutes/week	56.2 (51.0, 61.2)	52.3 (45.6, 59.0)	60.1 (53.9, 66.1)
Fruits & Vegetables Consumption			
>=5 servings/day	44.7 (36.6, 53.0)	37.0 (27.4, 47.7)	62.6 (50.9, 73.0)
<5 servings/day	49.5 (45.5, 53.4)	43.2 (38.2, 48.3)	55.9 (51.4, 60.3)
Current smokers			
No	52.2 (48.2, 56.3)	46.7 (41.1, 52.3)	56.4 (52.1, 60.6)
Yes	34.8 (29.9, 40.1)	33.9 (28.5, 39.7)	52.2 (36.0, 68.0)
Smokeless tobacco use			
No	49.3 (44.7, 53.8)	42.3 (36.9, 47.8)	59.1 (52.3, 65.6)
Yes	48.8 (44.5, 53.1)	42.5 (36.1, 49.3)	54.3 (49.7, 58.8)
Body Mass Index			
Normal	46.5 (42.2,50.8)	38.5 (33.5,43.9)	56.3 (50.7,61.8)
Underweight	32.9 (27.3,39.0)	30.0 (22.3,39.1)	36.6 (29.9,43.8)
Overweight	64.2 (58.9,69.1)	60.2 (54.4,65.7)	68.0 (59.5,75.4)
Obese	74.8 (64.3,83.0)	72.5 (57.7,83.6)	76.4 (62.6,86.3)
Waist Circumference			
Male: <90 cm/ Female: <80 cm	41.7 (37.3,46.1)	36.6 (31.4,42.1)	48.9 (43.4,54.4)
Male: >= 90 cm/ Female: >=80 cm	67.8 (63.7,71.6)	65.4 (58.4,71.8)	69.2 (63.0,74.7)
Self-reported diabetes			
No	47.5 (43.8, 51.1)	40.9 (36.0, 46.0)	54.9 (51.1, 58.7)
Yes	64.9 (55.2, 73.5)	60.5 (49.6, 70.5)	68.5 (56.2, 78.7)

¥Test was done between hypertension (Yes vs. No) and gender (Male vs. Female) for categories of the variables;
*Never married, widows, divorced and separated
**Hindu, Christian, Buddhist and others

Table 3: Factors associated with hypertension among elderly Bangladeshi people stratified by gender

Variables	Male				Female			
	COR	95% CI	AOR	95% CI	COR	95% CI	AOR	95% CI
Age (in Years)								
60 to 69	Ref		Ref		Ref		Ref	
70+	1.42***	1.19, 1.68	1.32**	1.09, 1.60	1.39***	1.17, 1.66	1.40**	1.15, 1.71
Place of Residence								
Rural	Ref		Ref		Ref		Ref	
Non-slum urban	1.72***	1.38, 2.15	0.93	0.69, 1.23	1.87***	1.48, 2.37)	1.18	0.88, 1.59
Slum	0.76	0.58, 1.00	0.71*	0.52, 0.96	0.88	0.69, 1.13	0.89	0.67, 1.17
Educational status								
No education	Ref		Ref		Ref		Ref	
Up to 5th grade	1.07	0.84, 1.37	0.92	0.71, 1.19	1.00	0.75, 1.33	0.95	0.70, 1.28
Up to 10th grade	1.62***	1.32, 1.98	1.25*	1.00, 1.56	1.71***	1.30, 2.25	1.27	0.94, 1.72
Above 10th grade	3.12***	2.44, 3.99	1.83***	1.38, 2.44	3.79**	1.68, 8.57	2.41	0.97, 6.00
Wealth Quintile								
Least wealthy	Ref		Ref		Ref		Ref	
Lower	0.95	0.74, 1.23	0.95	0.73, 1.24	1.28	0.98, 1.66	1.25	0.95, 1.64
Middle	1.37*	1.07, 1.75	1.19	0.91, 1.55	1.41*	1.08, 1.84	1.32	1.00, 1.75
Upper	1.23	0.96, 1.57	0.94	0.71, 1.23	1.19	0.91, 1.55	0.94	0.71, 1.26
Wealthiest	1.75***	1.36, 2.25	0.94	0.69, 1.28	1.66***	1.27, 2.16	1.04	0.76, 1.44
Marital Status								
Currently married	Ref		Ref		Ref		Ref	
Others£	1.37*	1.03, 1.82	1.13	0.82, 1.56	1.23*	1.02, 1.49	1.03	0.84, 1.28
Religion								
Muslim	Ref		Ref		Ref			
Others££	1.28*	1.03, 1.60	1.18	0.93, 1.51	0.99	0.79, 1.24	NA	NA
Physical Activity								
≥150 minutes/week	Ref		Ref		Ref		Ref	
<150 minutes/week	1.95***	1.66, 2.29	1.50***	1.25, 1.81	1.72***	1.45, 2.03	1.38**	1.15, 1.67
Fruits & Vegetables								
≥5 servings/day	Ref		Ref		Ref			
<5 servings/day	1.35*	1.06, 1.72	1.24	0.95, 1.60	0.98	0.68, 1.40	NA	NA
Current smoker (for ≥30 days)								
No	Ref		Ref		Ref		Ref	
Yes	0.55***	0.47, 0.65	0.74**	0.61, 0.89	0.65	0.41, 1.05	0.69	0.42, 1.15
Smokeless tobacco user (for ≥30 days)								
No	Ref		Ref		Ref		Ref	
Yes	0.80**	0.68, 0.94	0.86	0.72, 1.02	0.74**	0.63, 0.88	0.87	0.72, 1.04
Body Mass Index (BMI)								

Normal	Ref		Ref		Ref		Ref	
Underweight	0.62***	0.50, 0.77	NA	NA	0.56***	0.45, 0.69	NA	NA
Overweight	2.25***	1.83, 2.77	NA	NA	1.69***	1.35, 2.12	NA	NA
Obese	4.53***	2.96, 6.93	NA	NA	2.99***	2.10, 4.25	NA	NA
Waist Circumference								
Males <102 cm; Females <88 cm	Ref		Ref		Ref		Ref	
Males ≥102 cm; Females ≥88 cm	3.39***	2.78, 4.14	2.76***	2.22, 3.43	2.46***	2.06, 2.94	2.20***	1.82, 2.67
Self-reported Diabetes								
No	Ref		Ref		Ref		Ref	
Yes	2.22***	1.72, 2.88	1.36*	1.02, 1.82	2.45***	1.85, 3.23	1.82***	1.35, 2.45

* p < 0.05, ** p < 0.01, *** p < 0.001; CI: Confidence Interval; COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio; NA: Not applicable, these variables were not included in the adjusted analysis as these were dropped either due to the significance level was >0.2 in the crude analysis or due to high correlation with a covariate.

[£]Never married, widows, divorced and separated
[£££]Hindu, Christian, Buddhist and others

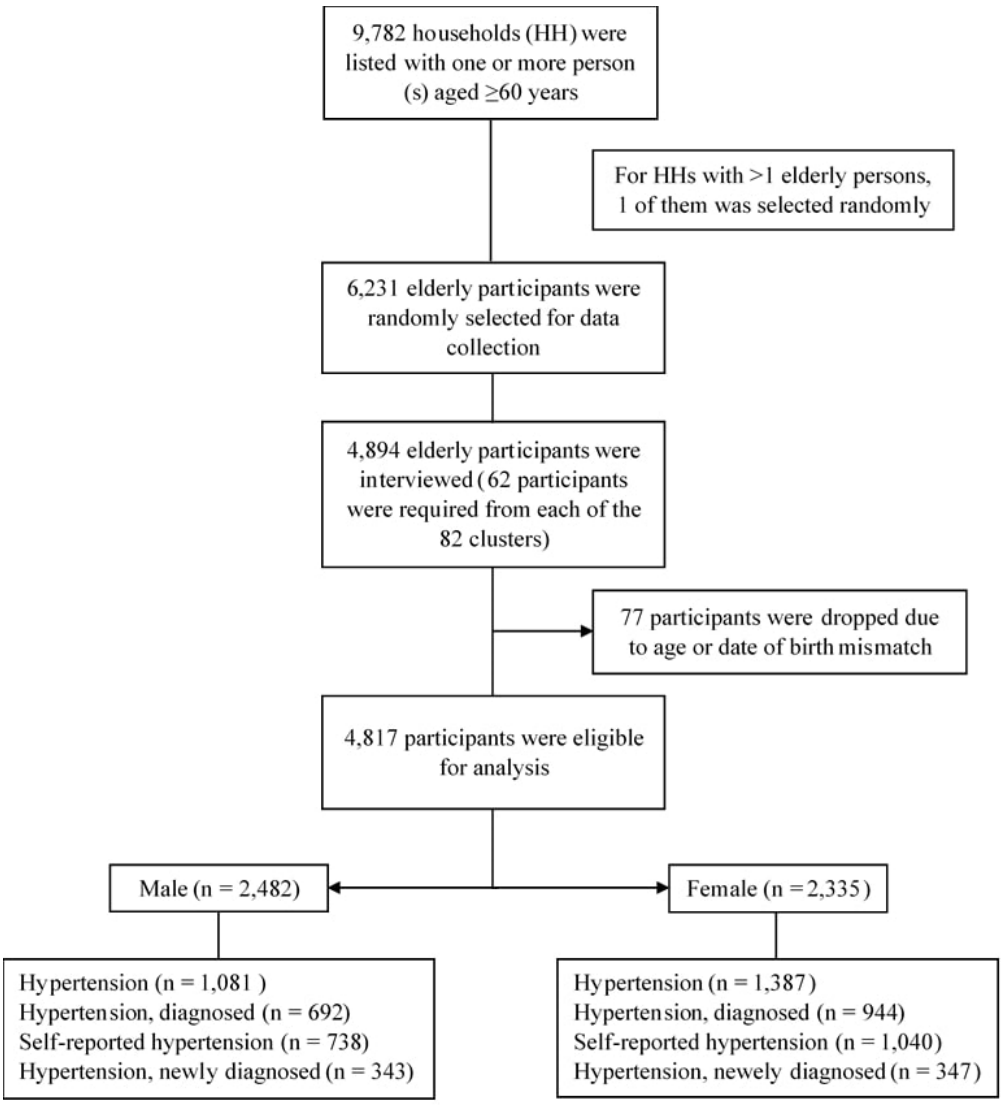

Figure 1: Study flow chart of participants selection (aged ≥60 years)

65x71mm (300 x 300 DPI)

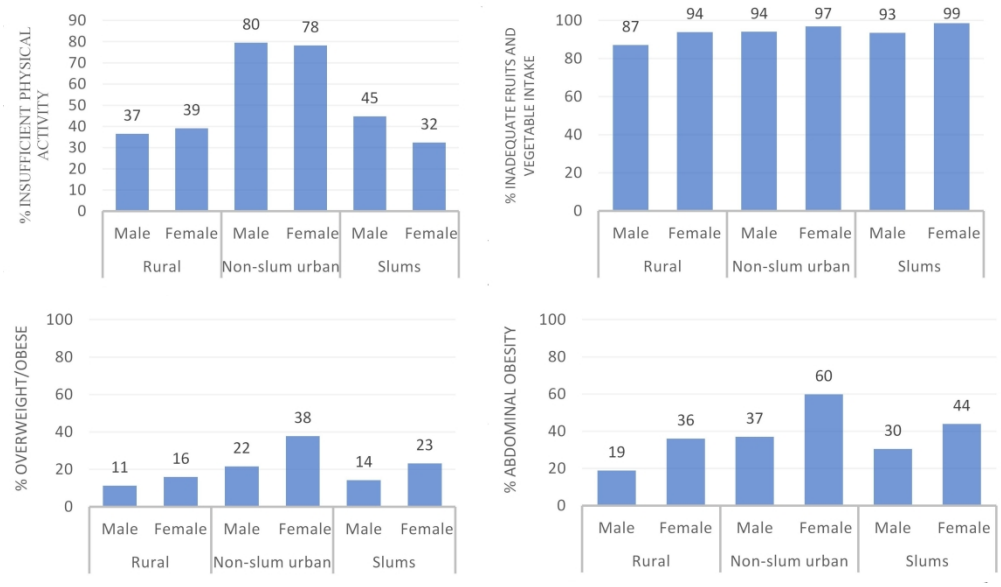

Figure 2: Selected behavioral and clinical characteristics by area of residence and gender

Supplementary Table 1: Factors associated with hypertension among elderly Bangladeshi people stratified by gender (adjusted for age, BMI, and waist circumference as continuous variables)

Variables	Male				Female			
	COR	95% CI	AOR	95% CI	COR	95% CI	AOR	95% CI
Age (years)[$]	1.02***	1.01, 1.03	1.03***	1.01, 1.04	1.02***	1.01, 1.03	1.03***	1.02, 1.04
Place of Residence								
Rural	Ref		Ref		Ref		Ref	
Non-slum urban	1.72***	1.38, 2.15	0.90	0.67, 1.20	1.87***	1.48, 2.37	1.10	0.81, 1.49
Slum	0.76	0.58, 1.00	0.69*	0.50, 0.93	0.88	0.69, 1.13	0.88	0.67, 1.17
Educational status								
No education	Ref		Ref		Ref		Ref	
Up to primary	1.07	0.84, 1.37	0.90	0.69, 1.17	1.00	0.75, 1.33	0.92	0.68, 1.26
Up to SSC	1.62***	1.32, 1.98	1.20	0.96, 1.5	1.71***	1.30, 2.25	1.21	0.9, 1.64
Above SSC	3.12***	2.44, 3.99	1.69***	1.26, 2.26	3.79**	1.68, 8.57	2.14	0.85, 5.36
Wealth Quintile								
Least wealthy (Q1)	Ref		Ref		Ref		Ref	
Lower (Q2)	0.95	0.74, 1.23	0.91	0.70, 1.2	1.28	0.98, 1.66	1.26	0.95, 1.66
Middle (Q3)	1.37*	1.07, 1.75	1.14	0.87, 1.49	1.41*	1.08, 1.84	1.32	0.99, 1.75
Upper (Q4)	1.23	0.96, 1.57	0.85	0.65, 1.13	1.19	0.91, 1.55	0.91	0.68, 1.22
Wealthiest (Q5)	1.75***	1.36, 2.25	0.83	0.61, 1.14	1.66***	1.27, 2.16	1	0.73, 1.39
Marital Status								
Currently married	Ref		Ref		Ref		Ref	
Others[£]	1.37*	1.03, 1.82	1.16	0.84,1.61	1.23*	1.02, 1.49	1.00	0.81, 1.24
Religion								
Muslim	Ref		Ref		Ref			
Others[££]	1.28*	1.03, 1.60	1.17	0.92, 1.50	0.99	0.79, 1.24	NA	NA
Physical Activity								
>=150 Minutes/week	Ref		Ref		Ref		Ref	
<150 Minutes/week	1.95***	1.66, 2.29	1.44***	1.19, 1.74	1.72***	1.45, 2.03	1.31**	1.09, 1.59
Fruits & Vegetables Consumption								
>=5 servings/day	Ref		Ref		Ref		Ref	
<5 servings/day	1.35*	1.06, 1.72	1.24	0.95, 1.61	0.98	0.68, 1.40	NA	NA
Currently smoking								
No	Ref		Ref		Ref		Ref	
Yes	0.55***	0.47, 0.65	0.81*	0.67, 0.97	0.65	0.41, 1.05	0.73	0.44, 1.23
Smokeless tobacco use								
No	Ref		Ref		Ref		Ref	
Yes	0.80**	0.68, 0.94	0.84	0.70, 1.00	0.74**	0.63, 0.88	0.87	0.73, 1.05
Body Mass Index (Kg/M^2)[$]	1.18***	1.15, 1.21	NA	NA	1.14***	1.11, 1.17	NA	NA

Waist Circumference (cm) [$]	1.06***	1.05, 1.07	1.06***	1.05, 1.07	1.05***	1.04, 1.06	1.05***	1.04, 1.05
Self-reported diabetes								
No	Ref		Ref		Ref		Ref	
Yes	2.22***	1.72, 2.88	1.26	0.94, 1.69	2.45***	1.85, 3.23	1.59**	1.18, 2.16

* p < 0.05, ** p < 0.01, *** p < 0.001; CI: Confidence Interval; COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio; NA: Not applicable, these variables were not included in the adjusted analysis as these were dropped due to the significance level was >0.2 in the crude analysis

$: Continuous variables

[£]Never married, widow/widower, divorced and separated

[££]Hindu, Buddhist, Christian and others

Supplementary Table 2: Factors associated with hypertension among elderly Bangladeshi people stratified by gender (adjusted for body mass index instead of waist circumference)

Variables	Male				Female			
	COR	95% CI	AOR	95% CI	COR	95% CI	AOR	95% CI
Age (years)[$]	1.02***	1.01, 1.03	1.02***	1.01, 1.04	1.02***	1.01, 1.03	1.03***	1.02, 1.04
Place of Residence								
Rural	Ref		Ref		Ref		Ref	
Non-slum urban	1.72***	1.38, 2.15	0.90	0.67, 1.20	1.87***	1.48, 2.37)	1.11	0.81, 1.50
Slum	0.76	0.58, 1.00	0.68*	0.50, 0.92	0.88	0.69, 1.13	0.90	0.68, 1.19
Educational status								
No education	Ref		Ref		Ref		Ref	
Up to 5th grade	1.07	0.84, 1.37	0.94	0.72, 1.22	1.00	0.75, 1.33	0.98	0.72, 1.33
Up to 10th grade	1.62***	1.32, 1.98	1.23	0.98, 1.54	1.71***	1.30, 2.25	1.29	0.95, 1.75
Above 10th grade	3.12***	2.44, 3.99	1.76***	1.32, 2.36	3.79**	1.68, 8.57	2.33	0.93, 5.81
Wealth Quintile								
Least wealthy	Ref		Ref		Ref		Ref	
Lower	0.95	0.74, 1.23	0.94	0.72, 1.23	1.28	0.98, 1.66	1.28	0.97, 1.69
Middle	1.37*	1.07, 1.75	1.17	0.89, 1.53	1.41*	1.08, 1.84	1.35	1.02, 1.81
Upper	1.23	0.96, 1.57	0.93	0.7, 1.23	1.19	0.91, 1.55	0.92	0.68, 1.24
Wealthiest	1.75***	1.36, 2.25	0.94	0.69, 1.28	1.66***	1.27, 2.16	1.03	0.74, 1.43
Marital Status								
Currently married	Ref		Ref		Ref		Ref	
Others[£]	1.37*	1.03, 1.82	1.11	0.80, 1.55	1.23*	1.02, 1.49	1.03	0.83, 1.27
Religion								
Muslim	Ref		Ref		Ref			
Others[££]	1.28*	1.03, 1.60	1.12	0.88, 1.43	0.99	0.79, 1.24	NA	NA

Physical Activity								
≥150 minutes/week	Ref		Ref		Ref		Ref	
<150 minutes/week	1.95***	1.66, 2.29	1.46***	1.21, 1.76	1.72***	1.45, 2.03	1.34**	1.10, 1.62
Fruits & Vegetables								
≥5 servings/day	Ref		Ref		Ref			
<5 servings/day	1.35*	1.06, 1.72	1.22	0.94, 1.59	0.98	0.68, 1.40	NA	NA
Currently smokers								
No	Ref		Ref		Ref		Ref	
Yes	0.55***	0.47, 0.65	0.79*	0.65, 0.95	0.65	0.41, 1.05	0.8	0.47, 1.35
Smokeless tobacco use								
No	Ref		Ref		Ref		Ref	
Yes	0.80**	0.68, 0.94	0.83*	0.7,1	0.74**	0.63, 0.88	0.87	0.72, 1.04
Body Mass Index (BMI)								
Normal	Ref		Ref		Ref		Ref	
Underweight	0.62***	0.50, 0.77	0.61***	0.49, 0.77	0.56***	0.45, 0.69	0.53***	0.42, 0.66
Overweight	2.25***	1.83, 2.77	1.96***	1.57, 2.45	1.69***	1.35, 2.12	1.62***	1.28, 2.05
Obese	4.53***	2.96, 6.93	3.7***	2.37, 5.79	2.99***	2.10, 4.25	2.59***	1.78, 3.75
Waist Circumference								
Male: <90 cm/ Female: <80 cm	Ref		Ref		Ref		Ref	
Male: >= 90 cm/ Female: >=80 cm	3.39***	2.78, 4.14	$	$	2.46***	2.06, 2.94	$	$
Self-reported Diabetes								
No	Ref		Ref		Ref		Ref	
Yes	2.22***	1.72, 2.88	1.32	0.98, 1.77	2.45***	1.85, 3.23	1.73***	1.28, 2.34

* p < 0.05, ** p < 0.01, *** p < 0.001; CI: Confidence Interval; COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio; NA: Not applicable, these variables were not included in the adjusted analysis as these were dropped due to the significance level was >0.2 in the crude analysis

$: Although waist circumference was used in the final model, BMI is used here to produce a supplementary table to show to results of the analysis using BMI instead of waist circumference.

[£]Never married, widow/widower, divorced and separated

[£££]Hindu, Buddhist, Christian and others

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	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	3-4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4-5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	*6-7*
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable
		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*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	5
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	5
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-8
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	7-8
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	7-9
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*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	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-9
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	12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-12
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	16

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

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