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Determinants of hypertension among adults in Bangladesh as per the Joint National Committee 7 and 2017 American College of Cardiology/American Hypertension Association hypertension guidelines

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Abstract

We investigated determinants of hypertension in Bangladesh using both Joint National Committee 7 (JNC7) and 2017 American College of Cardiology/American Hypertension Association (2017 ACC/AHA) guidelines. After reporting background characteristics, odds ratios (ORs) were obtained by multilevel logistic regression. Among 7839 respondents aged ≥ 35 years, 25.7% (n = 2016) and 48.0% (n = 3767) respondents had hypertension as per the JNC7 and 2017 ACC/AHA guidelines, respectively. The following factors were significant according to the 2017 ACC/AHA guideline: ≥ 65 years (adjusted OR [AOR]: 2.4, 95% confidence interval [CI]: 2.2–3.0), 55–64 years (AOR: 1.6, 95% CI: 1.4–1.9), and 45–54 years (AOR: 1.4, 95% CI: 1.3–1.6) age groups, females (AOR: 2.0, 95% CI: 1.7–2.2), overweight/obesity (AOR: 2.4, 95% CI: 2.0–2.8), diabetes (AOR: 1.4, 95% CI: 1.2–1.6), secondary (AOR: 1.2, 95% CI: 1.1–1.4), or college education level (AOR: 1.8, 95% CI: 1.4–2.3), middle (AOR: 1.3, 95% CI: 1.1–1.6), richer (AOR: 1.5, 95% CI: 1.2–1.8) or richest (AOR: 2.0, 95% CI: 1.6–2.4) wealth quintiles, residence in Khulna (AOR: 1.5, 95% CI: 1.2–1.9), and Rangpur (AOR: 1.7, 95% CI: 1.3–2.2) divisions. All factors were significant as per the JNC7 guideline too. Both guidelines found similar determinants. Prevention

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and control programs should prioritize increasing awareness among people with higher likelihood of hypertension.

Keywords

2017 ACC/AHA; Bangladesh; determinants; hypertension

Background

Globally, cardiovascular diseases contributed to an estimated 350 million disability-adjusted life years, 26 million years lived with disability, and 17.5 million deaths in 2015.^{1–3} Uncontrolled hypertension is one of the leading risk factors for cardiovascular diseases and a major contributor to global morbidities and mortalities.^{4,5} There have been substantial investigations about prevalence and determinants of hypertension in developed countries. Although recent estimates show that the burden of hypertension is more likely to increase in low- and middle-income countries (LMICs), limited data on this issue exist from these countries.^{4,6,7} Bangladesh is an example of an LMIC with limited data regarding the prevalence of hypertension.⁸ Similar to many LMICs, this country is facing a double disease burden with a simultaneous high prevalence of infectious and noncommunicable diseases because of ongoing epidemiologic and demographic transitions.^{8,9} The sixth Bangladesh Demographic and Health Survey 2011 (2011 BDHS), the most currently available, nationally representative survey from Bangladesh, estimated that about 26% of people aged 35 years have hypertension.⁸ In addition, the World Health Organization's (WHO) "The Non-Communicable Disease Risk Factor Survey Bangladesh" concluded that the prevalence of hypertension was as high as 18% among people aged 25 years.⁹

The prevalence of hypertension could also change following application of the guideline used to classify hypertension.^{10–12} In November 2017, "The American College of Cardiology/American Heart Association (2017 ACC/AHA) Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults" was released. This new guideline modified the cutoffs for systolic blood pressure (SBP) and diastolic blood pressure (DBP) to categorize hypertension.¹⁰ The previously recommended guidelines such as the World Health Organization-International Society of Hypertension (WHO-ISH) Guideline recommended the hypertension cutoffs for SBP and DBP as 140 and 90 mm Hg, respectively.¹³ However, the 2017 ACC/AHA reduced the cutoffs for SBP/DBP to 130/80 mm Hg, 10 mm Hg lower than the previous cutoff points.^{10,13} This lower cutoff point was classified as the prehypertensive range per the previous guidelines; the new guideline replaced the term "prehypertension" with "elevated blood pressure."¹⁰ Previous studies have also estimated the proportion of people who would be newly classified as hypertensive because of the modified guideline. Muntner et al. estimated that the new prevalence would be 14.7% higher among the US population compared with the previously recommended Joint National Committee 7 (JNC7) cutoff points of 140/90 mm Hg.¹¹ In addition, in a prior publication examining differences in hypertension prevalence comparing the 2017 ACC/AHA and JNC7 guidelines, we showed that about 22.3% of people in Bangladesh would now be classified as hypertensive because of lowering the blood pressure threshold.¹⁴

Similar prevalence difference was observed in Nepal.¹⁵ Prevalence helps to estimate the burden of disease, whereas determinants or risk factors are helpful for identifying the people who should be prioritized for targeting in awareness, control, and prevention programs.^{16,17} Taking into account the large proportion of prehypertensive people who would now be labeled as hypertensive,^{10,11,14} the determinants of “new” hypertension could also differ, as earlier studies found that “prehypertension” (as per previous guidelines) might vary according to background characteristics of the study participants.^{18–20} Altering the blood pressure level to classify hypertension could also alter the associated factors that impact the prevalence or likelihood of hypertension. Although the prevalence of hypertension has been estimated for Bangladesh using the 2017 ACC/AHA guideline,¹⁴ determinants of hypertension under this new guideline are yet to be identified.

In the present study, we evaluated the determinants of hypertension using both JNC7 and 2017 ACC/AHA guide-lines and then compared the determinants across the two guidelines. Previous studies found that age, sex, body mass index (BMI), concomitant diabetes, education level, wealth status, and place of residence have relationships with prevalence and likelihood of hypertension in Bangladesh.^{7,18,19,21–25} We investigated the association of hypertension with these factors using the nationally representative 2011 BDHS data.

Methods

Ethical Approval

The 2011 BDHS protocol was approved by the Institutional Review Boards of the ICF International, Rockville, MD, USA and Bangladesh Medical Research Council, Dhaka, Bangladesh. Informed verbal consent was obtained from all survey participants.

Data Source

The 2011 BDHS was a cross-sectional survey conducted from July 2011 to January 2012. It aimed to collect a representative sample from all urban and rural noninstitutionalized people living in seven administrative divisions in Bangladesh. Among several other health indicators, the 2011 BDHS measured blood pressure and blood glucose levels for men and women aged ≥ 35 years.⁸

First, the 2011 Population and Housing Census was used to obtain the sampling frame. The sampling frame contained a list of enumeration areas (EA) that were the primary sampling unit. Households were selected in two stages. A total of 600 EAs (207 and 393 from urban and rural regions, respectively) were obtained in the first phase. Then, the households were listed in these selected EAs. After randomly selecting about 30 households from each EA, the sample was designed to have 18,000 households. From these households, 4311 females and 4524 males aged ≥ 35 years were eligible for blood pressure measurement; about 92% females and 86% males participated. The survey design, methodologies, sample size calculation, and results have been published with the 2011 BDHS report.⁸

Measures

Blood pressure level was measured by a trained technician using the “LIFE SOURCE UA-767” Plus Blood Pressure Monitor model, a standardized device recommended by the WHO. The device has small, medium, and large cuff sizes. Blood pressure was measured three times with a 10-minute interval between each measurement in seated position during household interview. The data collector obtained other information from the respondent during this 10-minute interval. The final blood pressure level was obtained from the average of the last two measurements. Participants also reported if they were taking any blood pressure or blood glucose-lowering drugs.⁸ As per the JNC7, hypertension was present if a person had SBP/DBP $\geq 140/90$ mm Hg or if the person was taking any blood pressure lowering drugs.^{11,26} The 2017 ACC/AHA defines hypertension as the SBP/DBP of $\geq 130/80$ mm Hg or if the person was taking any blood pressure lowering drugs.^{10,11} The details of the blood pressure measurement methods have been reported with the 2011 BDHS report.⁸

Supplemental Table 1 describes all study variables including their categories. Participants reported their age, sex, education level, and household wealth components. The height, weight, and fasting blood glucose were also measured. A person was labeled as diabetic if she/he had a blood glucose level ≥ 7 mmol/L or was taking any antidiabetic drugs. The BMI was obtained by dividing weight (in kilogram) by squared height (m^2); a BMI ≥ 25 kg/m^2 was considered overweight/obese. We adopted the WHO-recommended cutoff point for BMI to define overweight/obesity. We also reported the prevalence (Supplemental Tables 2 and 3) and analysis (Supplemental Table 4) results as the Asian-specific BMI criterion to define overweight/obesity, which categorizes overweight/obesity as BMI ≥ 23 kg/m^2 .²⁷ The place (ie, rural or urban) and administrative divisions of residence were also recorded. Quintile-stratified household wealth status was computed by the principal component analysis of the household construction materials (such as materials used to build walls, roofs, and floors), water source, sanitation facilities, electricity, and other belongings.^{8,28,29}

Statistical Analyses

The background characteristics of the study participants were reported according to the presence of hypertension (as per both JNC7 and 2017 ACC/AHA guidelines), as well as the overall population. All variables were presented with numbers and percentages. The hierarchical structure (ie, multi-stage cluster sampling design) of the dataset was considered to report weighted frequencies. After this, multilevel logistic regression analyses were conducted to obtain odds ratios (ORs) and significance levels (ie, P values) as per both guidelines; both crude ORs (CORs) and adjusted ORs (AORs) were reported with 95% confidence intervals (CI). All explanatory variables were considered to be nested in a cluster for multilevel analysis.³⁰ Variables with a significance level of <0.2 from the crude analysis were used in the multivariable analysis. This significance level has been recommended to be sufficient for adjustment in multivariable models for reducing the residual confounding.³⁰ Multicollinearity among the variables was checked by variance inflation factors. Stata 14.0 (College Station, TX, USA) was used for data analysis.³¹

Results

Table 1 describes the overall background characteristics of the survey sample, as well as the background characteristics of the respondents according to the presence of hypertension as per both guidelines. A total of 7839 respondents were included in this analysis. About 25.7% (n = 2016) and 48.0% (n = 3767) of participants had hypertension according the JNC7 and 2017 ACC/AHA guidelines, respectively. Approximately half of the respondents were females, 50.6% (n = 3963). The proportion of female respondents was higher among hypertensive people of both guidelines. The proportion of diabetic people among total respondents was 11.0% (n = 826); these proportions were 16.5% (n = 320) and 13.8% (n = 502) among hypertensive participants of JNC7 and 2017 ACC/AHA guidelines, respectively. Only 13.4% (n = 1019) of the respondents were overweight/obese; hypertensive participants of both guidelines had higher percentage of overweight/obese individuals compared with people with no hypertension. About two-thirds of the overall respondents had no formal education, 63.1% (n = 4945). Most participants were from rural regions, 76.7% (n = 6009). Other characteristics were similar across hypertensive people of both guidelines.

Table 2 shows CORs and adjusted ORs of the risk factors for hypertension as per two guidelines. Based on the JNC7 guideline, age was significantly associated in adjusted analysis with the highest odds for age group of ≥ 65 years (AOR: 4.9, 95% CI: 4.2–5.9), followed by 55–64 years (AOR: 2.5; 95% CI: 2.1–3.0) and 45–54 years (AOR: 1.9, 95% CI: 1.6–2.2) age groups. Female had higher odds of hypertension compared with males (AOR: 2.4, 95% CI: 2.0–2.7). Being overweight/obese (AOR: 2.2, 95% CI: 1.9–2.6) and having diabetes (AOR: 1.5, 95% CI: 1.2–1.7) had positive association with hypertension. The following factors also had significant adjusted association with hypertension as per the JNC7 guideline: secondary education level (AOR: 1.2, 95% CI: 1.0–1.5), college or above education level (AOR: 1.9, 95% CI: 1.4–2.4), poorer (AOR: 1.3, 95% CI: 1.1–1.6), middle (AOR: 1.3, 95% CI: 1.0–1.6), richer (AOR: 1.5, 95% CI: 1.2–1.8), and richest (AOR: 2.1, 95% CI: 1.7–2.6) wealth quintiles, and finally living in Khulna (AOR: 1.4, 95% CI: 1.1–1.8) and Rangpur (AOR: 1.6, 95% CI: 1.3–2.1) divisions. The prevalence (Supplemental Table 3) and AORs (Supplemental Table 4) according to both overweight/obese definitions were similar.

Although the magnitude of the association was slightly different, the same factors also had significant associations with hypertension as per the 2017 ACC/AHA guideline (Table 2). Similar to the JNC7 cutoff, we found a relationship between hypertension and all three age groups, ≥ 65 years (AOR: 2.4, 95% CI: 2.2–3.0), 55–64 years (AOR: 1.6; 95% CI: 1.4–1.9), and 45–54 years (AOR: 1.4, 95% CI: 1.3–1.6). Among other investigated factors, female sex (AOR: 2.0, 95% CI: 1.7–2.2), overweight/obesity (AOR: 2.4, 95% CI: 2.0–2.8), diabetes (AOR: 1.4, 95% CI: 1.2–1.6), secondary education level (AOR: 1.2, 95% CI: 1.1–1.4), college or above education level (AOR: 1.8, 95% CI: 1.4–2.3), middle (AOR: 1.3, 95% CI: 1.1–1.6), richer (AOR: 1.5, 95% CI: 1.2–1.8), and richest (AOR: 2.0, 95% CI: 1.6–2.4) wealth quintiles, living in Khulna (AOR: 1.5, 95% CI: 1.2–1.9) and Rangpur (AOR: 1.7, 95% CI: 1.3–2.2) divisions also had significant association with hypertension.

Discussion

This study investigated determinants of hypertension in Bangladesh using two hypertension definitions as per the JNC7 and 2017 ACC/AHA guidelines. We found that all factors that were significant using the JNC7 guideline's cutoff points also had significant relationships with hypertension as per the 2017 ACC/AHA definition. The following characteristics had higher likelihood of hypertension as per both cutoff points: age, sex, overweight/obesity, diabetes, education level, and division of residence. The determinants we identified based on the JNC7 cutoff points were also identified by previous studies that investigated hypertension in Bangladesh using the 2011 BDHS dataset.^{18,19,21} Thus, based on the new cutoff points, our findings further strengthen the significance of these known risk factors for hypertension in this study population.

Earlier studies have elaborated on the probable explanation for the difference in prevalence and odds of hypertension because of several background characteristics. Higher than normal body weight (ie, overweight/obesity) and diabetes are two known major modifiable risk factors for hypertension.^{18,19} These conditions share a complex metabolic pathway and interact with one another. Higher body weight and diabetes could result in atherosclerosis that ultimately leads to hypertension.^{32–34} Coexistence of these three conditions increases the risk of stroke and other cardiovascular diseases.^{3,32} With the ongoing epidemiologic and demographic transitions, the prevalence of said conditions is more likely to increase in Bangladesh.^{35,36} Similar to the pathophysiological mechanism mentioned previously, previous studies have observed that hypertension, overweight/obesity, and diabetes share common risk factors, including socioeconomic conditions.^{18,19,21,36,37} To reduce the overall burden of hypertension, a multifaceted approach addressing all these factors is crucial.

Age group is also a known determinant of hypertension.^{18,21} About 58% of people aged 65 years have hypertension as per the 2017 ACC/AHA estimate.¹⁴ This higher likelihood or prevalence is because of structural changes in arterial walls with increasing age, which cause stiffness in the arteries.³⁸ People with advancing age also have increased risk of other noncommunicable diseases such as diabetes and overweight/obesity that could contribute to the development of hypertension.^{18,19,21} Because of the ongoing demographic transition, the proportion of people with advancing age is also expected to increase in this country.⁸ Because age is not a modifiable risk factor, intervention strategies targeting aging adults should emphasize more awareness to control and prevent hypertension. Previous studies that investigated awareness and control of hypertension in Bangladesh found a lower awareness and control level among hypertensive people.^{19,21}

Females had higher odds of hypertension compared with their male counterparts as per both guidelines; all the articles that investigated determinants of hypertension in Bangladesh observed similar association.^{18,19,21} Several explanations have been put forward including differences in sociodemographic characteristics described in Supplemental Table 5 that could contribute to this higher prevalence or likelihood among females.⁸ We also reported how the prevalence of hypertension differs according to sex (Supplemental Table 6). However, further research is required about the pathophysiology, behavioral, and

sociodemographic risk factors that contribute to this higher prevalence or odds of hypertension among females in Bangladesh considering limited investigation about this.

Similar to the JNC7, both higher education level and household wealth status had significant relationships with hypertension as per the 2017 ACC/AHA guideline. Earlier studies showed that people with a higher socioeconomic status in LMICs follow more sedentary lifestyles; such behavior could be a major impediment for preventing and controlling hypertension.^{39,40} Moreover, these findings are different compared with findings from high-income countries, where people with a higher socioeconomic status have lower prevalence and likelihood of hypertension because of their increased awareness level.^{41,42} Therefore, increasing awareness of hypertension among individuals with higher socioeconomic status in Bangladesh is imperative for controlling blood pressure levels.

Khulna and Rangpur divisions had the highest likelihood of hypertension. Besides the socioeconomic differences among divisions in Bangladesh,⁸ salinity in drinking water of Khulna division could be a contributing factor.^{18,43,44} Hypertension prevention and control programs need to prioritize these regions, especially given the consequences of higher drinking water salinity because of climate change.

Although previous studies that used JNC7 cutoff points found higher prevalence of hypertension in urban regions, these studies reported marginal or no statistically significant association between hypertension and rural–urban place of residence.^{21,35} Prevalence of prehypertension was also higher in urban regions.⁸ Classifying a large proportion of prehypertensive people (as per the JNC7 guideline) in urban regions as hypertensive (according to the 2017 ACC/AHA cutoff points) could contribute to the change in prevalence. The higher prevalence and crude odds of hypertension could be because of the difference in sociodemographic characteristics of the people in these regions. Overall, urban people have higher socioeconomic status in Bangladesh.²¹ In addition, the prevalence of overweight/obese, diabetes, and hyperlipidemia is also higher in urban regions.^{19,22,35,37} Previous studies also concluded that there is a clustering of risk factors for noncommunicable diseases in urban regions such as higher prevalence of diabetes and overweight/obesity that might cause this difference.^{23,45}

The cutoff points for categorizing hypertension were different; however, the determinants were similar. These similarities could be because of the fact that prehypertension had similar determinants.^{21,24} Reidentification of these known determinants with a new definition of hypertension signifies that prevention and control programs should continue prioritizing these characteristics. The prevention and control efforts should be increased because of labeling a large proportion of people as hypertensive who had “prehypertension” or “high–normal blood pressure” as per the former guidelines.^{10,13,26} As stated previously, the determinants we investigated here were examined in the “multiplicative scale” (ie, prevalence OR) that might not substantially alter the magnitude of association in that scale; however, in the “additive scale” (ie, absolute difference), the updated prevalence because of the new categorization had an overall increase of more than 20% in Bangladesh.¹⁴ The prevalence almost doubled after applying the new 2017 ACC/AHA guideline.^{11,14} This increment in prevalence highlights that prevention and control efforts should focus on

raising awareness among the people with higher prevalence and odds of hypertension. It is important to address these determinants to reduce the prevalence or burden of modifiable factors such as overweightness/obesity and diabetes. Although some factors such as age and sex are not modifiable, increasing awareness in these particular population subgroups to control blood pressure levels could help minimize negative consequences of hypertension.¹⁻³ A recent analysis of noncommunicable diseases' control and prevention programs revealed that the planning and monitoring of these programs in Bangladesh were inadequate.⁴⁶ To combat a disease such as hypertension, successful implementation and monitoring of these programs are crucial.

Our study has several notable strengths. First, the 2011 BDHS covered rural and urban areas in all administrative divisions within Bangladesh. This large coverage provided a nationally representative sample, which made the survey generalizable for Bangladesh. The response rate of the survey was also high. The survey used validated research instruments that further increased the authenticity of our results.⁸ To our knowledge, this is the first epidemiologic study that investigated determinants of hypertension in Bangladesh as per the 2017 ACC/AHA cutoff points and compared it with the determinants as per the JNC7 cutoff points.

Despite the strengths mentioned previously, the limitations of the present article also merit discussion. Although both guidelines recommend longitudinal measurement of blood pressure,^{10,11} the 2011 BDHS measured blood pressure on only one day and was thus a cross-sectional survey; this technique may have caused some misclassification bias.⁸ The efficacy or skill level of some survey staff could also lead to misclassification bias.¹⁹ We did not investigate some known risk factors for hypertension such as stress, physical activity, dietary habits, or dyslipidemia because of the limitation of the dataset. Furthermore, as the data were cross-sectional, causality could not be established because of lack of temporal evidence of associations.⁸

Conclusions

This study reconfirmed the significance of known risk factors from the JNC7 guideline's cutoff point using the new 2017 ACC/AHA hypertension definition. Prevention and control programs should continue prioritizing these associated characteristics with greater efforts. It is important to address the modifiable factors on a priority basis to reduce the overall prevalence or complications of hypertension. Overall, people with higher socioeconomic status, diabetes, overweight/obesity, advancing age, female sex, or residence in Khulna and Rangpur divisions need more awareness to reduce the overall burden and minimize future negative consequences associated with hypertension.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. Vos T, Allen C, Arora M, Barber RM, Bhutta ZA, Brown A, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;388(10053):1545–602. [PubMed: 27733282]
2. Wang H, Naghavi M, Allen C, Barber RM, Bhutta ZA, Carter A, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;388(10053):1459–544. [PubMed: 27733281]
3. GBD 2016 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 333 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2017; 390(10100):1260–344. [PubMed: 28919118]
4. Forouzanfar MH, Liu P, Roth GA, Ng M, Biryukov S, Marczak L, et al. Global burden of hypertension and systolic blood pressure of at least 110 to 115 mm Hg, 1990–2015. *JAMA* 2017;317(2):165–82. [PubMed: 28097354]
5. GBD 2015 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet* 2016;388(10053):1603–58. [PubMed: 27733283]
6. Boutayeb A The double burden of communicable and non-communicable diseases in developing countries. *Trans R Soc Trop Med Hyg* 2006;100(3):191–9. [PubMed: 16274715]
7. Ibrahim MM, Damasceno A. Hypertension in developing countries. *Lancet* 2012;380(9841):611–9. [PubMed: 22883510]
8. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011 [Internet]. Dhaka, Bangladesh Available at: <https://dhsprogram.com/pubs/pdf/fr265/fr265.pdf>.
9. Bangladesh Society of Medicine, World Health Organization, Ministry of Health and Family Welfare. Noncommunicable disease risk factor survey Bangladesh. Bangladesh, Available at: http://www.searo.who.int/entity/non-communicable_diseases/data/Bangladesh_2010_STEPS_Survey_Report.pdf; 2010.
10. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Dennison Himmelfarb C, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart association task force on clinical practice guidelines. *Hypertension* 2018;71(6): e13–115. [PubMed: 29133356]
11. Muntner P, Carey RM, Gidding S, Jones DW, Taler SJ, Wright JT, et al. Potential U.S. Population impact of the 2017 American College of Cardiology/American Heart Association high blood pressure guideline. *J Am Coll Cardiol* 2018;71(2):109–18. [PubMed: 29146532]
12. Daniels SR. What is the prevalence of childhood hypertension?: it depends on the definition. *JAMA Pediatr* 2018;172(6):519. [PubMed: 29710181]
13. Chalmers J, MacMahon S, Mancia G, Whitworth J, Beilin L, Hansson L, et al. 1999 World Health Organization-International Society of Hypertension Guidelines for the management of hypertension. Guidelines sub-committee of the World Health Organization. *Clin Exp Hypertens* 1999;21(5–6):1009–60. [PubMed: 10423121]

14. Kibria GMA, Swasey K, Choudhury A, Burrowes V, Stafford KA, Uddin SMI, et al. The new 2017 ACC/AHA guideline for classification of hypertension: changes in prevalence of hypertension among adults in Bangladesh. *J Hum Hypertens* 2018;32(8–9):608–16. [PubMed: 29899377]
15. Kibria GMA, Swasey K, Kc A, Mirbolouk M, Sakib MN, Sharmeen A, et al. Estimated change in prevalence of hypertension in Nepal following application of the 2017 ACC/AHA guideline. *JAMA Network Open* 2018;1(3):e180606. [PubMed: 30646022]
16. Antay-Bedregal D, Camargo-Revello E, Alvarado GF. Associated factors vs risk factors in cross-sectional studies. *Patient Prefer Adherence* 2015;9:1635–6. [PubMed: 26622171]
17. Barroga EF, Kojima T. Research study designs: an appraisal for peer reviewers and science editors. *Eur Sci Ed* 2013;39:44–5.
18. Chowdhury MAB, Uddin MJ, Haque MR, Ibrahimou B. Hypertension among adults in Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovasc Disord* 2016;25:16–22.
19. Harshfield E, Chowdhury R, Harhay MN, Bergquist H, Harhay MO. Association of hypertension and hyperglycaemia with socioeconomic contexts in resource-poor settings: the Bangladesh Demographic and Health Survey. *Int J Epidemiol* 2015;44(5):1625–36. [PubMed: 26150556]
20. Anchala R, Kannuri NK, Pant H, Khan H, Franco OH, Di Angelantonio E, et al. Hypertension in India: asystematic review and meta-analysis of prevalence, awareness, and control of hypertension. *J Hypertens* 2014;32(6):1170–7. [PubMed: 24621804]
21. Rahman M, Zaman MM, Islam JY, Chowdhury J, Ahsan HN, Rahman R, et al. Prevalence, treatment patterns, and risk factors of hypertension and prehypertension among Bangladeshi adults. *J Hum Hypertens* 2018;32(5):334–48. [PubMed: 29230005]
22. Biswas T, Islam MS, Linton N, Rawal LB. Socio-economic inequality of chronic non-communicable diseases in Bangladesh. *PLoS One* 2016;11(11):e0167140. [PubMed: 27902760]
23. Zaman MM, Bhuiyan MR, Karim MN, Zaman Moniruz, Rahman MM, Akanda AW, et al. Clustering of non-communicable diseases risk factors in Bangladeshi adults: an analysis of STEPS survey 2013. *BMC Public Health* 2015;15:659. [PubMed: 26169788]
24. Khanam MA, Lindeboom W, Razzaque A, Niessen L, Milton AH. Prevalence and determinants of prehypertension and hypertension among the adults in rural Bangladesh: findings from a community-based study. *BMC Public Health* 2015;15:659. [PubMed: 26169788]
25. Khan RJ, Stewart CP, Christian P, Schulze KJ, Wu L, LeClerq SC, et al. A cross-sectional study of the prevalence and risk factors for hypertension in rural Nepali women. *BMC Public Health* 2013;13:55. [PubMed: 23336578]
26. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, et al. The seventh report of the Joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. *JAMA* 2003;289(19):2560–72. [PubMed: 12748199]
27. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004;363(9403):157–63. [PubMed: 14726171]
28. Filmer D, Pritchett LH. Estimating wealth effects without expenditure data-or tears: an application to educational enrollments in States of India. *Demography* 2001;38(1):115. [PubMed: 11227840]
29. Jolliffe IT, Cadima J. Principal component analysis: a review and recent developments. *Philos Trans A Math Phys Eng Sci* 2016;374(2065):20150202. [PubMed: 26953178]
30. Maldonado G, Greenland S. Simulation study of confounder-selection strategies. *Am J Epidemiol* 1993;138(11):923–36. [PubMed: 8256780]
31. StataCorp. 2015 Stata Statistical Software: Release 14. College Station, TX: StataCorp LP.
32. Sowers JR, Epstein M, Frohlich ED. Diabetes, hypertension, and cardiovascular disease : an update. *Hypertension* 2001;37(4):1053–9. [PubMed: 11304502]
33. Sowers JR, Khoury S, Standley P, Zemel P, Zemel M. Mechanisms of hypertension in diabetes. *Am J Hypertens* 1991;4(2 Pt 1):177–82. [PubMed: 2021449]
34. Cheung BMY, Li C. Diabetes and hypertension: is there a common metabolic pathway? *Curr Atheroscler Rep* 2012;14(2):160–6. [PubMed: 22281657]

35. Biswas T, Uddin MJ, Mamun AA, Pervin S, P Garnett S. Increasing prevalence of overweight and obesity in Bangladeshi women of reproductive age: findings from 2004 to 2014. *PLoS One* 2017;12(7):e0181080. [PubMed: 28753680]
36. Bishwajit G Household wealth status and overweight and obesity among adult women in Bangladesh and Nepal: household wealth status and obesity among women. *Obes Sci Pract* 2017;3(2):185–92. [PubMed: 28706731]
37. Biswas T, Garnett SP, Pervin S, Rawal LB. The prevalence of underweight, overweight and obesity in Bangladeshi adults: data from a national survey. *PLoS One* 2017;12(5):e0177395. [PubMed: 28510585]
38. Pinto E Blood pressure and ageing. *Postgrad Med J* 2007;83(976):109–14. [PubMed: 17308214]
39. Bhurosy T, Jeewon R. Overweight and obesity epidemic in developing countries: a problem with diet, physical activity, or socioeconomic status? *ScientificWorldJournal* 2014;2014:1–7.
40. Lear SA, Teo K, Gasevic D, Zhang X, Poirier PP, Rangarajan S, et al. The association between ownership of common household devices and obesity and diabetes in high, middle and low income countries. *CMAJ* 2014; 186(4):258–66. [PubMed: 24516093]
41. Scholes S, Bajekal M, Love H, Hawkins N, Raine R, O'Flaherty M, et al. Persistent socioeconomic inequalities in cardiovascular risk factors in England over 1994–2008: a time-trend analysis of repeated cross-sectional data. *BMC Public Health* 2012;12: 129. [PubMed: 22333887]
42. Sampson UKA, Edwards TL, Jahangir E, Munro H, Wariboko M, Wassef MG, et al. Factors associated with the prevalence of hypertension in the Southeastern United States: insights from 69 211 blacks and whites in the southern community cohort study. *Circ Cardiovasc Qual Outcomes* 2014;7(1):33–54. [PubMed: 24365671]
43. Talukder MRR, Rutherford S, Huang C, Phung D, Islam MZ, Chu C. Drinking water salinity and risk of hypertension: a systematic review and meta-analysis. *Arch Environ Occup Health* 2017;72(3):126–38. [PubMed: 27064986]
44. Scheelbeek PF, Chowdhury MAH, Haines A, Alam DS, Hoque MA, Butler AP, et al. Drinking water salinity and raised blood pressure: evidence from a cohort study in coastal Bangladesh. *Environ Health Perspect* 2017; 125(5):057007. [PubMed: 28599268]
45. Ahmed SM, Hadi A, Razzaque A, Ashraf A, Juvekar S, Ng N, et al. Clustering of chronic non-communicable disease risk factors among selected Asian populations: levels and determinants. *Glob Health Action* 2009;28:2.
46. Biswas T, Pervin S, Tanim MIA, Niessen L, Islam A. Bangladesh policy on prevention and control of noncommunicable diseases: a policy analysis. *BMC Public Health* 2017;17(1):582. [PubMed: 28629430]

Table 1Background characteristics of the study population, n (%)^{*}

Characteristics	Overall, N = 7839	Respondents With Hypertension Under Guidelines			
		JNC7		2017 ACC/AHA	
		Yes (n = 2016)	No (n = 5823)	Yes (n = 3767)	No (n = 4072)
Age (y)					
35–44	2850 (36.3)	487 (24.1)	2363 (40.6)	1211 (32.1)	1639 (40.2)
45–54	2267 (28.9)	567 (28.1)	1700 (29.2)	1079 (28.6)	1188 (29.2)
55–64	1332 (17.0)	402 (20.0)	930 (16.0)	683 (18.1)	649 (16.0)
65	1390 (17.7)	560 (27.8)	830 (14.2)	794 (21.1)	596 (14.6)
Sex					
Male	3876 (49.5)	753 (37.4)	3123 (53.6)	1606 (42.6)	2270 (55.8)
Female	3963 (50.5)	1263 (62.6)	2700 (46.4)	2161 (57.4)	1802 (44.2)
Obese/overweight					
No	6568 (86.6)	1480 (77.0)	5088 (89.8)	2892 (80.1)	3676 (92.5)
Yes	1019 (13.4)	441 (23.0)	578 (10.2)	720 (19.9)	299 (7.5)
Diabetes					
No	6700 (89.0)	1625 (83.5)	5075 (90.9)	3127 (86.2)	3573 (91.7)
Yes	826 (11.0)	320 (16.5)	506 (9.1)	502 (13.8)	324 (8.3)
Education					
No formal education	4945 (63.1)	1289 (63.9)	3656 (62.8)	2378 (63.1)	2567 (63.0)
Primary	1443 (18.4)	325 (16.1)	1118 (19.2)	623 (16.5)	820 (20.1)
Secondary	972 (12.4)	228 (11.3)	744 (12.8)	463 (12.3)	509 (12.5)
College or above	479 (6.1)	174 (8.6)	305 (8.6)	303 (8.0)	176 (4.3)
Household wealth quintile					
Poorest	1524 (19.4)	286 (14.2)	1238 (21.3)	582 (15.4)	942 (23.1)
Poorer	1508 (19.2)	326 (16.2)	1182 (20.3)	621 (16.5)	887 (21.8)
Middle	1551 (19.8)	346 (17.2)	1205 (20.7)	703 (18.7)	848 (20.8)
Richer	1619 (20.7)	447 (22.2)	1172 (20.1)	834 (22.1)	785 (19.3)
Richest	1637 (20.9)	611 (30.3)	1026 (17.6)	1026 (27.3)	611 (15.0)
Place of residence					

Characteristics	Overall, N = 7839	Respondents With Hypertension Under Guidelines			
		JNC7		2017 ACC/AHA	
		Yes (n = 2016)	No (n = 5823)	Yes (n = 3767)	No (n = 4072)
Urban	1830 (23.3)	597 (29.6)	1233 (21.2)	1061 (28.2)	768 (18.9)
Rural	6009 (76.7)	1419 (70.4)	4590 (78.8)	2705 (71.8)	3304 (81.1)
Division					
Barisal	464 (5.9)	115 (5.7)	349 (6.0)	208 (5.5)	256 (6.3)
Chittagong	1334 (17.0)	293 (14.5)	1041 (17.9)	569 (15.1)	764 (18.8)
Dhaka	2514 (32.1)	680 (33.7)	1834 (31.5)	1285 (34.1)	1229 (30.2)
Khulna	1020 (13.0)	308 (15.3)	712 (12.2)	566 (15.0)	454 (11.1)
Rajshahi	1135 (14.5)	269 (13.3)	867 (14.9)	486 (12.9)	649 (15.9)
Rangpur	922 (11.8)	259 (12.9)	663 (11.4)	474 (12.6)	448 (11.0)
Sylhet	449 (5.7)	92 (4.6)	357 (6.1)	178 (4.7)	271 (6.7)

JNC, Joint National Committee; ACC/AHA, American College of Cardiology/American Heart Association.

* Column percentage; numbers may not add up to total because of missing values.

Table 2

Results of logistic regression analyses to compare crude and adjusted ORs for the factors associated with hypertension according to guideline

Traits	COR (95% CI)		AOR (95% CI)	
	JNC7	2017 ACC/AHA	JNC7	2017 ACC/AHA
Age (y)				
35–44	Ref.	Ref.	Ref.	Ref.
45–54	1.7 *** (1.5, 2.0)	1.3 *** (1.2, 1.5)	1.9 *** (1.6, 2.2)	1.4 *** (1.3, 1.6)
55–64	2.4 *** (2.0, 2.8)	1.5 *** (1.3, 1.8)	2.5 *** (2.1, 3.0)	1.6 *** (1.4, 1.9)
65	3.8 *** (3.2, 4.4)	2.1 *** (1.8, 2.4)	4.9 *** (4.2, 5.9)	2.4 *** (2.2, 3.0)
Sex				
Male	Ref.	Ref.	Ref.	Ref.
Female	1.9 *** (1.7, 2.1)	1.7 *** (1.6, 1.9)	2.4 *** (2.0, 2.7)	2.0 *** (1.7, 2.2)
Overweight/Obesity				
No	Ref.	Ref.	Ref.	Ref.
Yes	2.6 *** (2.3, 3.0)	3.1 *** (2.6, 3.5)	2.2 *** (1.9, 2.6)	2.4 *** (2.0, 2.8)
Diabetes				
No	Ref.	Ref.	Ref.	Ref.
Yes	2.0 *** (1.7, 2.3)	1.7 *** (1.5, 2.0)	1.5 *** (1.2, 1.7)	1.4 *** (1.2, 1.6)
Education				
No Formal Education	Ref.	Ref.	Ref.	Ref.
Primary	0.9 * (0.8, 1.0)	0.8 ** (0.7, 0.9)	1.0 (0.9, 1.2)	1.0 (0.9, 1.1)
Secondary	0.9 (0.8, 1.1)	1.0 (0.8, 1.1)	1.2 * (1.0, 1.5)	1.2 * (1.1, 1.4)
College or Higher	1.4 *** (1.2, 1.7)	1.6 *** (1.3, 1.9)	1.9 *** (1.4, 2.4)	1.8 *** (1.4, 2.3)
Household Wealth Quintile				
Poorest	Ref.	Ref.	Ref.	Ref.
Poorer	1.2 (1.0, 1.4)	1.1 (0.9, 1.3)	1.3 * (1.1, 1.6)	1.1 (0.9, 1.3)
Middle	1.3 * (1.0, 1.5)	1.4 *** (1.2, 1.6)	1.3 * (1.0, 1.6)	1.3 *** (1.1, 1.6)
Richer	1.7 *** (1.4, 2.0)	1.7 *** (1.4, 2.0)	1.5 *** (1.2, 1.8)	1.5 *** (1.2, 1.8)
Richest	2.6 *** (2.2, 3.1)	2.7 *** (2.3, 3.2)	2.1 *** (1.7, 2.6)	2.0 *** (1.6, 2.4)

Traits	COR (95% CI)		AOR (95% CI)	
	JNC7	2017 ACC/AHA	JNC7	2017 ACC/AHA
Place of Residence				
Urban	1.6 ^{***} (1.4, 1.8)	1.7 ^{***} (1.4, 1.9)	1.1 (0.9, 1.3)	1.1 (1.0, 1.3)
Rural	Ref.	Ref.	Ref.	Ref.
Division				
Barisal	Ref.	Ref.	Ref.	Ref.
Chittagong	0.9 (0.7, 1.2)	0.9 (0.7, 1.2)	0.8 (0.6, 1.1)	0.8 (0.6, 1.1)
Dhaka	1.2 (0.9, 1.5)	1.4 [*] (1.1, 1.7)	1.2 (0.9, 1.5)	1.3 (1.0, 1.6)
Khulna	1.3 [*] (1.1, 1.7)	1.6 ^{***} (1.2, 2.0)	1.4 [*] (1.1, 1.8)	1.5 ^{**} (1.2, 1.9)
Rajshahi	1.0 (0.8, 1.3)	1.0 (0.8, 1.3)	1.2 (0.9, 1.5)	1.0 (0.8, 1.3)
Rangpur	1.3 [*] (1.0, 1.7)	1.4 ^{**} (1.1, 1.9)	1.6 ^{***} (1.3, 2.1)	1.7 ^{***} (1.3, 2.2)
Sylhet	0.9 (0.7, 1.1)	0.9 (0.7, 1.1)	0.9 (0.7, 1.1)	0.8 (0.6, 1.1)

ACC/AHA, American College of Cardiology/American Heart Association; AOR, adjusted odds ratio; CI, confidence interval; COR, Crude odds ratio; JNC, Joint National Committee.

* $P < .05$

** $P < .01$

*** $P < .001$.