International Journal of Cardiology Hypertension 1 (2019) 100006

Contents lists available at ScienceDirect

International Journal of Cardiology Hypertension

journal homepage: www.journals.elsevier.com/international-journal-of-cardiology-hypertension/

Research Paper

Sex differences in prevalence and associated factors of prehypertension and hypertension among Bangladeshi adults

Gulam Muhammed Al Kibria [a,*], Vanessa Burrowes [b], Allysha Choudhury [b], Atia Sharmeen [c], Krystal Swasey [a]

[a] Department of Epidemiology and Public Health, School of Medicine, University of Maryland, Baltimore, MD 21201, USA
[b] Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD 21205, USA
[c] School of Community Health and Policy, Morgan State University, Baltimore, MD 21251, USA

ARTICLE INFO

Keywords:
Non-communicable diseases
Hypertension
Prehypertension
Determinants
Risk factors
Developing countries
Bangladesh
Prevalence
Sex

ABSTRACT

Globally, complications of raised blood pressure are fundamental public health issues. There has been limited research if prevalence and risk factors vary by sex in many countries, including Bangladesh. We stratified the prevalence and associated factors of prehypertension and hypertension according to sex in Bangladesh.

This cross-sectional study analyzed the Bangladesh Demographic and Health Survey 2011 data. After estimating prevalence according to sex, multilevel logistic regression was applied to obtain associated factors.

This study analyzed data of 3876 males and 3962 females aged ≥35 years. The prevalence of hypertension was 19.4% (95% confidence interval [CI]: 18.0–21.0) among males and 31.9% (95% CI: 30.1–33.6) among females. Among both males and females, prevalence and odds of hypertension increased with age, overweight/obesity, diabetes, upper wealth status, and residence in some divisions. Education level was a significant positive correlate of hypertension for males only.

Males and females had similar prevalence of prehypertension, 27.2% (95% CI: 25.6–28.8) and 27.6% (95% CI: 26.0–29.2), respectively. Characteristics such as older age, overweight/obesity, and diabetes were associated with higher prevalence and odds of prehypertension among females; prehypertension among males was associated with advancing age, overweight/obesity, education level, wealth status, and division of residence.

In Bangladesh, almost half of the males and females could have increased risks of complications resulting from hypertension and prehypertension. Addressing the characteristics associated with higher prevalence or odds of these conditions is crucial. Several common risk factors indicate that a common prevention and control strategy could work for both sexes.

1. Introduction

Hypertension is a leading risk factor for cardiovascular diseases, and responsible for a large number of deaths and disabilities each year [1,2]. It develops faster among individuals with prehypertension or among people who already have higher than normal blood pressure [1]. Prehypertensive people are also at a greater risk of developing cardiovascular diseases than normotensive people. Moreover, if prehypertensive persons could maintain a normal pressure level by early diagnosis and modify their lifestyles accordingly, progression to hypertension may be delayed [1,3]. Recent estimates suggest that the prevalence of raised blood pressure levels is increasing similar to epidemic rates in many low- and middle-income countries (LMICs), while the prevalence is static in high-income countries [1,2,4,5]. Globally, about one-third of adults have hypertension [6]. Several behavioral risk factors including unhealthy dietary habits, tobacco use, physical inactivity, and excessive alcohol contribute to this higher prevalence of prehypertension and hypertension, while education level and wealth status influence behavioral risk factors [1,7,8]. Moreover, although prevalence, trends, and risk factors of prehypertension or hypertension are regularly monitored in high-income

Abbreviations: BDHS, Bangladesh Demographic and Health Survey; BBS, Bangladesh Bureau of Statistics; CI, Confidence interval; DBP, Diastolic Blood Pressure; EA, Enumeration Area; AOR, Adjusted Odds Ratio; SBP, Systolic Blood Pressure; VIF, Variance Inflation Factor; WHO, World Health Organization.

* Corresponding author.
E-mail addresses: gkibria1@outlook.com (G.M. Al Kibria), vburrow1@jhmi.edu (V. Burrowes), allyshac@umich.edu (A. Choudhury), ataiasharmeenmoushumee@gmail.com (A. Sharmeen), kswasey@umaryland.edu (K. Swasey).

https://doi.org/10.1016/j.ijchy.2019.100006
Received 8 February 2019; Received in revised form 9 April 2019; Accepted 23 April 2019
Available online 30 April 2019

countries, there is a lack of recent data from many LMICs, including Bangladesh [4,9,10].

The Bangladesh Demographic and Health Survey (BDHS) 2011 is the last nationally representative survey that obtained the prevalence of high blood pressure in the country. The survey estimated the overall prevalence of hypertension as 25.7% among adults aged ≥35 years in the country [10]. The prevalence of hypertension in BDHS 2011 was 31.9% in females and 19.4% in males. Prehypertension prevalence was roughly equal among both males and females, about 27% [10,11]. Additionally, studies from other countries have demonstrated that prevalence and risk factors of hypertension differ according to sex [12–14]. Both behavioral and biological characteristics contribute to the sex differences in the prevalence and likelihood of these conditions[15,16]. Sex and socio-demographic conditions simultaneously play a significant role in developing hypertension and prehypertension. As such, identification and stratification of these factors by sex are important for the development of strategies to prevent hypertension and prehypertension in the country. Furthermore, strategies to prevent or manage hypertension could differ due to different distributions of risk factors among males and females [12–14]. A study from Bangladesh found that awareness and control of hypertension may also differ according to sex [17]. Although earlier studies investigated the risk factors for hypertension in Bangladesh [18–22], none have stratified and examined these factors for prehypertension and hypertension among males and females. This study aims to address these existing gaps in the literature by investigating the prevalence and associated factors of prehypertension and hypertension by sex amongst people in Bangladesh.

2. Methods

2.1. Data source

This study analyzed the BDHS 2011 data. Mitra and Associates implemented this cross-sectional survey from July 2011 to January 2012. One of its specific objectives was to obtain nationally representative measures of blood pressure and blood glucose levels for all non-institutionalized males and females aged 35 years or older. Details of the BDHS 2011 including survey design, methodologies, sample size, questionnaires, and findings have been reported elsewhere [10].

Briefly, the BDHS 2011 used a two-stage cluster sampling design to select respondents from households. Using the Bangladesh Population and Housing Census 2011, a list of enumeration areas (EA) was created. The EA was the primary sampling unit. To obtain 600 EAs with a probability proportion of the size of an EA, 207 and 393 clusters were obtained from urban and rural areas, respectively. Then, the households were listed; each EA had an average of 30 households. All males and females above 35 years of age living in one-third of these enlisted households were eligible for blood pressure measurements. From these households, 4311 females and 4524 males were eligible to participate. Among eligible participants, blood pressure was measured for 92% of females and 86% of males [10].

2.2. Measures

To measure blood pressure, the World Health Organization (WHO) recommended 'LIFE SOURCE® UA-767 Plus Blood Pressure Monitor' model was used. With the appropriate cuff size (i.e., small, medium, or large), blood pressure was measured three times at an interval of 10 min between each measurement. During that interval, other data were collected from the participant. To report the final pressure, the mean of the second and third measurements was used [10]. The quality of the data was ensured by four quality control teams. The Seventh Joint National Committee guideline's cut-off points for systolic/diastolic blood pressure measurements were used to categorize blood pressure levels [23]. This paper adapted the same guideline to classify prehypertension and hypertension (Supplemental Table 1). Furthermore, the same cutoffs to define hypertension were also recommended by other guidelines, including the WHO-International Society of Hypertension(24), the European [25], Canadian [26], and Australian [27] hypertension guidelines.

2.3. Outcome variables

A person was considered hypertensive if the systolic blood pressure was ≥140 mmHg or the diastolic blood pressure was ≥90 mmHg, or if the person was taking any blood pressure lowering medications. A person without hypertension, but who had systolic and diastolic blood pressures within 120–139 and 80–89 mmHg, respectively was categorized as prehypertensive [23]. Participants reported if they were taking prescribed blood pressure lowering drugs [10].

2.4. Explanatory variables

Potential determinants were selected based on literature searches and the structure of the BDHS 2011 dataset [10]. The body mass index (BMI) was obtained by dividing weight (in kg) by the square of individual's height (in m^2). A BMI ≥25 kg/m^2 was used to categorize a person as overweight/obese [28]. An individual with fasting plasma glucose levels ≥7.0 mmol/L was considered to have diabetes [29]. Participants reported their age, sex (i.e., male or female), education level, place (i.e., rural or urban), and division of residence. Education levels were categorized as no formal education, primary (i.e., at least five completed school years), and secondary or above (i.e., at least ten or more completed school years). Bangladesh had seven administrative divisions in 2011. Principal component analysis of household construction materials and ownership of assets was used to obtain wealth status of households; the wealth status was stratified into quintiles [10].

2.5. Ethical approval

Secondary and anonymized BDHS 2011 data was available for scientific and academic use upon approval from the ICF International, Maryland, USA; the permission for using the data was obtained in March 2017 [10]. The survey protocol was approved by the Institutional Review Boards of the ICF International and Bangladesh Medical Research Council, Dhaka, Bangladesh. All participants provided verbal informed consent.

2.6. Statistical analyses

The weighted percentage was used to report the background characteristics and prevalence of hypertension and prehypertension in the studied population. Categorical variables were reported with numbers and percentages while continuous variables were reported with median and interquartile ranges (IQR). Then, we conducted multilevel logistic regression to obtain the odds ratios (ORs) of both prehypertension and hypertension separately for both sexes. For both elevated pressure levels, normal pressure level was the reference category. Variables with a predetermined significance level (0.20) in crude analyses were included in the multivariable adjustment [30]. ORs with 95% confidence intervals (CIs) and significance levels were reported separately for males and females. To check multi-collinearity among variables before adjusting for other confounders, variance inflation factors (VIFs) were assessed. Stata 14.0 (Stata Corp, College Station, TX) was used to analyze the data of this study [31]; the 'svy' command allowed adjustments of the cluster sampling design in the survey and calculation of the weighted frequency for selected variables(10).

3. Results

Table 1 describes the study participants. This analysis included 3876 males and 3963 females. The median age of males and females was 50

Table 1
Characteristics of the survey participants with blood pressure measurements, BDHS 2011 (N = 7839)[a].

Characteristics	Male (n = 3876)			Female (n = 3963)			Both
	Overall	Prehypertension (n = 1053)	Hypertension (n = 753)	Overall	Prehypertension (n = 1092)	Hypertension (n = 1263)	
SBP, Median (IQR), mmHg	114 (104–125)	121 (116–127)	141 (127–154)	117 (106–133)	122 (116–127)	141 (127–157)	115 (105–129)
DBP, Median (IQR), mmHg	76 (69–84)	82 (80–85)	91 (83–97)	79 (72–87)	82 (80–85)	91 (69–84)	78 (70–85)
Blood pressure categories							
Normal Pressure	2070 (53.4)	NA	NA	1608 (40.6)	NA	NA	3678 (46.9)
Prehypertension	1053 (27.2)	NA	NA	1092 (27.6)	NA	NA	2145 (27.4)
Controlled on medication	126 (3.2)	NA	NA	250 (6.3)	NA	NA	376 (4.8)
Stage 1 hypertension	430 (11.1)	NA	NA	624 (15.8)	NA	NA	1054 (13.4)
Stage 2 hypertension	197 (5.1)	NA	NA	388 (9.8)	NA	NA	586 (7.5)
Age (in years)							
Median (IQR)	50 (41–60)	48 (40–59)	54 (46–65)	48 (40–59)	47 (40–58)	48 (44–65)	49 (41–60)
35–44	1317 (33.6)	369 (35.0)	157 (20.8)	1565 (39.1)	447 (40.9)	330 (26.1)	2882 (36.3)
45–54	1216 (31.0)	327 (31.1)	226 (29.9)	1070 (26.7)	288 (26.4)	341 (27.0)	2286 (28.8)
55–64	644 (16.4)	170 (16.1)	146 (19.4)	711 (17.7)	194 (17.8)	256 (20.3)	1355 (17.1)
≥65	748 (19.0)	187 (17.8)	225 (29.8)	662 (16.5)	163 (14.9)	336 (26.6)	1409 (17.8)
Overweight/obesity							
No	3428 (90.8)	883 (87.1)	606 (83.8)	3143 (82.3)	868 (82.5)	874 (72.9)	6571 (86.6)
Yes	346 (9.2)	130 (12.9)	117 (16.2)	675 (17.7)	184 (17.5)	324 (27.1)	1021 (13.4)
Diabetes mellitus							
No	3313 (89.3)	907 (89.5)	611 (84.2)	3388 (88.8)	940 (89.5)	1015 (83.1)	6702 (89.0)
Yes	397 (10.7)	106 (10.5)	114 (15.8)	429 (11.2)	111 (10.5)	206 (16.9)	826 (11.0)
Education level							
No Education	1479 (37.7)	354 (33.6)	238 (31.6)	3511 (87.6)	969 (88.7)	1051 (83.2)	4990 (62.9)
Primary	1098 (28.0)	296 (28.1)	182 (24.2)	362 (9.0)	97 (8.8)	143 (11.3)	1460 (18.4)
Secondary or above	1348 (34.3)	403 (38.3)	334 (44.3)	133 (3.3)	26 (2.4)	69 (5.5)	1481 (18.7)
Wealth quintile							
Poorest	770 (19.6)	165 (15.6)	99 (13.1)	759 (18.9)	218 (20.0)	188 (14.9)	1529 (19.3)
Poorer	764 (19.5)	174 (16.5)	120 (15.9)	749 (18.7)	195 (17.9)	206 (16.3)	1513 (19.1)
Middle	766 (19.5)	206 (19.6)	126 (16.7)	801 (20.0)	224 (20.5)	220 (17.4)	1567 (19.8)
Richer	795 (20.3)	236 (22.4)	165 (21.9)	836 (20.9)	231 (21.2)	282 (22.3)	1631 (20.6)
Richest	831 (21.2)	272 (25.8)	244 (32.3)	862 (21.5)	224 (20.5)	367 (29.1)	1693 (21.3)
Place of residence							
Urban	956 (24.3)	306 (29.1)	232 (30.8)	936 (23.4)	248 (22.7)	365 (28.9)	1892 (23.8)
Rural	2969 (75.7)	747 (70.9)	521 (69.2)	3071 (76.6)	845 (77.3)	898 (71.1)	6040 (76.2)
Division of residence							
Barisal	230 (5.9)	57 (5.4)	41 (5.5)	239 (6.0)	61 (5.6)	74 (5.8)	469 (5.9)
Chittagong	618 (15.7)	157 (14.9)	104 (13.8)	721 (18.0)	186 (17.1)	189 (15.0)	1339 (16.9)
Dhaka	1268 (32.3)	344 (32.7)	247 (32.8)	1295 (32.3)	379 (34.7)	433 (34.3)	2563 (32.3)
Khulna	515 (13.1)	157 (14.9)	121 (16.0)	509 (12.7)	143 (13.1)	187 (14.8)	1024 (12.9)
Rajshahi	584 (14.9)	142 (13.5)	97 (12.9)	570 (14.2)	139 (12.7)	172 (13.6)	1155 (14.6)
Rangpur	488 (12.4)	147 (14.0)	110 (14.6)	437 (10.9)	123 (11.2)	150 (11.9)	926 (11.7)
Sylhet	221 (5.6)	49 (4.6)	34 (4.5)	235 (5.9)	62 (5.7)	58 (4.6)	456 (5.8)

BDHS: Bangladesh Demographic & Health Survey; IQR: Interquartile range; NA: Not applicable; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.
[a] Numbers and column percentage unless otherwise specified.

(IQR: 41–60) and 48 (IQR: 40–59) years, respectively. The median systolic and diastolic blood pressures of females were higher than their male counterparts. The proportion of overweight/obese people was 13.4% (n = 1021). A greater proportion of females were obese/overweight compared to males, 17.7% (n = 675) and 9.2% (n = 346), respectively. About 11.0% (n = 826) respondents had diabetes; hypertensive participants had a higher proportion of diabetes than the normotensive or prehypertensive people among both sexes. About two-thirds of the participants had no formal education, 62.9% (n = 4990); both elevated blood pressure levels had a greater proportion of people with any formal education among females and males. About 24.3% (n = 956) of males and 23.4% (n = 936) of females were from urban areas. Among both males and females, prehypertensive or hypertensive people have a greater proportion of people from urban regions. About one-third of the respondents were from Dhaka (32.3%, n = 2563), followed by Chittagong (16.9%, n = 1339), Rajshahi (14.6%, n = 1155), Khulna (12.9%, n = 1024), Rangpur (11.7%, n = 926), Barisal (5.9%, n = 469), and Sylhet (5.8%, n = 456).

Table 2 presents the prevalence of prehypertension and hypertension according to background characteristics among males and females. The overall prevalence of hypertension was 19.4% (95% CI: 18.0–21.0) among males. An additional 27.2% (95% CI: 25.6–28.8) of males had prehypertension. Among females, the overall prevalence of prehypertension and hypertension was 27.6% (95% CI: 26.0–29.2) and 31.9% (95% CI: 30.1–33.6), respectively. Prevalence of prehypertension was similar according to many background characteristics while the prevalence of hypertension varied across all investigated characteristics. In all categories and sub-categories, the prevalence of hypertension was higher among females compared to their male counterparts. Hypertension also increased with age among both males and females. The prevalence of hypertension was highest among males who were ≥65 years of age followed by males in the 55–64, 45–54, and 35–44 years age groups with prevalence of 30.4% (95% CI: 26.6–34.5), 23.1% (95% CI: 19.7–26.9), 18.7% (95% CI: 16.4–21.2), and 12.1% (95% CI: 10.2–14.2), respectively. Similarly, females with ≥65 years age had 51.5% prevalence (95% CI: 46.9–56.1); females with 55–64, 45–54, and 35–44 years age groups had the prevalence of 36.6% (95% CI: 32.6–40.9), 32.1% (95% CI: 28.6–35.8), and 21.3% (95% CI: 19.1–23.7), respectively. Males and females with diabetes, overweight/obesity, and urban residence had higher prevalence of hypertension. Although education level did not show any ordinal pattern with respect to prevalence of prehypertension among females, it showed an ordinal pattern with hypertension among

Table 2
Prevalence (with 95% CI) of prehypertension & hypertension according to background characteristics among males & females, BDHS 2011.

Traits	Male		Female	
	Prehypertension	Hypertension	Prehypertension	Hypertension
Age (in years)				
35–44	28.4% (25.7, 31.3)	12.1% (10.2, 14.2)	28.8% (26.1, 31.6)	21.3% (19.1, 23.7)
45–54	27.1% (24.4, 30.0)	18.7% (16.4, 21.2)	27.2% (24.2, 30.3)	32.1% (28.6, 35.8)
55–64	26.9% (23.2, 30.9)	23.1% (19.7, 26.9)	27.7% (24.0, 31.8)	36.6% (32.6, 40.9)
≥65	25.3% (22.0, 28.9)	30.4% (26.6, 34.5)	25.1% (21.2, 29.3)	51.5% (46.9, 56.1)
Overweight/obesity				
No	25.8% (24.1, 27.5)	17.7% (16.2, 19.3)	27.6% (25.8, 29.5)	27.8% (26.0, 29.8)
Yes	37.7% (32.3, 43.5)	33.9% (28.8, 39.3)	27.3% (23.4, 31.6)	48.1% (43.8, 52.5)
Diabetes				
No	27.4% (25.6, 29.2)	18.4% (16.9, 20.1)	27.7% (26.0, 29.6)	30.0% (28.2, 31.8)
Yes	26.8% (22.1, 32.1)	28.7% (23.9, 34.1)	25.8% (21.6, 30.6)	48.1% (42.7, 53.5)
Education level				
No Education	24.1% (21.7, 26.6)	16.2% (14.0, 18.7)	27.9% (26.2, 29.6)	30.2% (28.4, 32.1)
Primary	27.2% (24.2, 30.5)	16.7% (14.4, 19.4)	27.2% (22.1, 33.1)	40.2% (34.8, 45.9)
Secondary or above	30.5% (27.9, 33.3)	25.3% (22.7, 28.0)	20.2% (13.7, 28.8)	53.1% (43.5, 62.5)
Wealth quintile				
Poorest	21.5% (18.0, 25.4)	12.9% (10.4, 15.9)	28.8% (25.2, 32.7)	24.8% (21.4, 28.5)
Poorer	22.9% (19.5, 26.6)	15.8% (13.1, 18.9)	26.1% (22.5, 30.0)	27.6% (24.3, 31.1)
Middle	27.3% (23.8, 31.0)	16.7% (13.8, 19.9)	28.2% (24.8, 31.9)	27.7% (24.1, 31.5)
Richer	29.9% (26.2, 33.8)	20.9% (17.8, 24.3)	27.9% (24.5, 31.5)	34.0% (30.4, 37.8)
Richest	33.9% (30.5, 37.6)	30.4% (27.3, 33.6)	26.8% (23.2, 30.7)	43.9% (39.8, 48.0)
Place of residence				
Urban	33.2% (30.0, 36.5)	25.2% (22.8, 27.6)	27.3% (24.2, 30.7)	40.2% (36.6, 43.9)
Rural	25.3% (23.5, 27.2)	17.6% (15.9, 19.6)	27.6% (25.8, 29.5)	29.4% (27.4, 31.4)
Division				
Barisal	24.9% (21.0, 29.3)	18.1% (14.8, 22.0)	25.6% (21.5, 30.2)	31.0% (26.8, 35.4)
Chittagong	25.6% (21.9, 29.7)	16.9% (13.5, 20.9)	25.9% (22.6, 29.5)	26.3% (22.8, 30.2)
Dhaka	27.8% (24.6, 31.2)	19.9% (16.9, 23.3)	29.8% (26.3, 33.5)	34.0% (30.3, 38.0)
Khulna	30.6% (26.9, 34.4)	23.5% (19.4, 28.1)	28.2% (24.6, 32.1)	37.0% (32.5, 41.7)
Rajshahi	24.7% (21.1, 28.7)	16.9% (13.8, 20.6)	24.7% (20.9, 28.8)	30.5% (26.9, 34.4)
Rangpur	30.1% (25.8, 34.7)	22.5% (18.8, 26.6)	28.3% (24.6, 32.2)	34.5% (29.7, 39.7)
Sylhet	22.5% (18.6, 26.9)	15.4% (11.6, 20.3)	26.7% (22.6, 31.2)	25.2% (20.5, 30.4)
Overall	27.2% (25.6, 28.8)	19.4% (18.0, 21.0)	27.6% (26.0, 29.2)	31.9% (30.1, 33.6)

BDHS: Bangladesh Demographic & Health Survey, CI: Confidence interval.

females, and prehypertension and hypertension among males. Among divisions, Khulna had the highest prevalence of hypertension for both males and females; 23.5% (95% CI: 19.4–28.1) and 37.0% (95% CI: 32.5–41.7), respectively. Fig. 1 summarizes the comparison of prevalence of these blood pressure stages among males and females.

Table 3 reports the results of multivariable multilevel logistic regression analysis. We also reported the crude ORs with the Supplemental Table 2. Although the determinants of prehypertension were different among males and females, the determinants of hypertension were similar. Among males, the following characteristics had significantly greater odds of prehypertension: age group ≥65 years (adjusted [AOR]: 1.6; 95% CI: 1.3–2.1), overweight/obesity (AOR: 2.3; 95% CI: 1.7–3.1), middle (AOR: 1.4; 95% CI: 1.1–1.8), richer (AOR: 1.7; 95% CI: 1.3–2.2), and richest (AOR: 2.1; 95% CI 1.5–2.9) wealth quintiles, and living in Rangpur division (AOR: 1.7; 95% CI: 1.2–2.4). Females with the following factors had significantly greater odds of prehypertension: 55–64 (AOR: 1.5; 95% CI: 1.1–1.9) and ≥65 (AOR: 2.3; 95% CI: 1.7–3.0) years age groups, overweight/obesity (AOR: 1.7; 95% CI: 1.3–2.2), and diabetes (AOR: 1.5; 95% CI: 1.1–2.0). Age groups demonstrated dose-response relationships in their association with

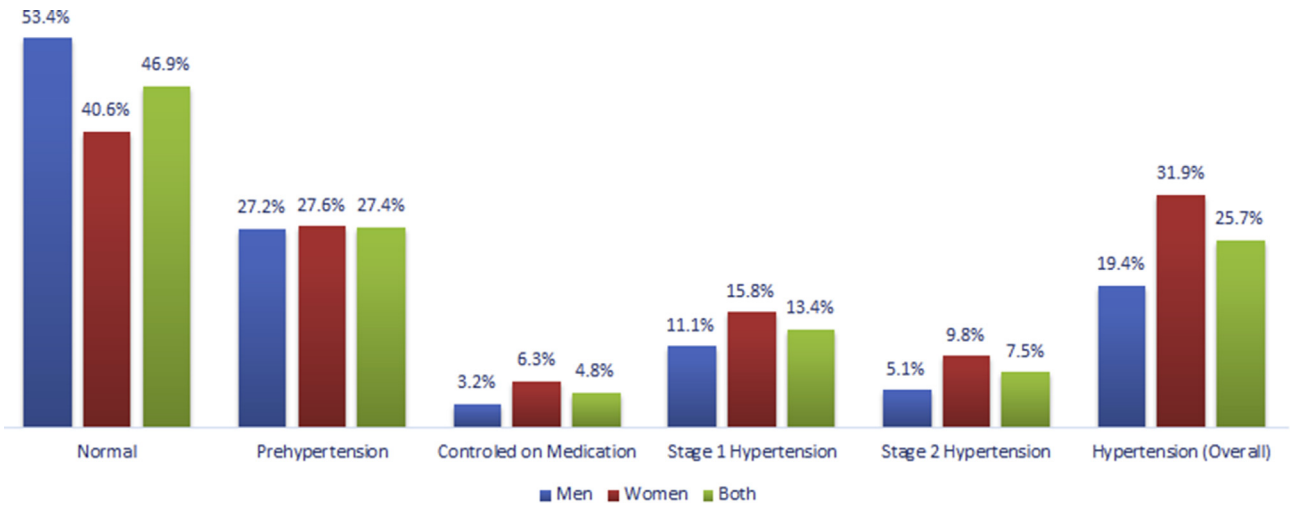

Fig. 1. Prevalence of Blood Pressure Stages by Sex, Bangladesh Demographic and Health Survey 2011.

Table 3
Factors associated with prehypertension and hypertension stratified by sex, BDHS 2011.

Traits	Male		Female	
	Prehypertension vs Normal Pressure	Hypertension vs Normal Pressure	Prehypertension vs Normal Pressure	Hypertension vs Normal Pressure
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Age (in years)				
35–44	Ref.	Ref.	Ref.	Ref.
45–54	1.2 (1.0,1.4)	2.0*** (1.6,2.6)	1.2 (1.0,1.5)	2.1*** (1.7,2.6)
55–64	1.2 (0.9,1.5)	3.0*** (2.2,4.0)	1.5** (1.1,1.9)	3.0*** (2.3,3.9)
≥65	1.6*** (1.3,2.1)	6.1*** (4.6,8.3)	2.3*** (1.7,3.0)	7.7*** (5.7,10.3)
Overweight/Obesity				
No	Ref.	Ref.	Ref.	Ref.
Yes	2.3*** (1.7,3.1)	3.2*** (2.3,4.5)	1.7*** (1.3,2.2)	3.0*** (2.4,3.9)
Diabetes				
No	NA	Ref.	Ref.	Ref.
Yes	NA	1.4* (1.1,1.9)	1.5** (1.1,2.0)	1.9*** (1.5,2.6)
Education level				
No Education	Ref.	Ref.	NA	Ref.
Primary	1.0 (0.8,1.3)	1.0 (0.8,1.3)	NA	0.9 (0.7,1.3)
Secondary or above	1.4* (1.1,1.8)	1.5** (1.2,2.0)	NA	1.0 (0.6,1.7)
Wealth quintile				
Poorest	Ref.	Ref.	Ref.	Ref.
Poorer	1.1 (0.8,1.4)	1.2 (0.8,1.7)	0.8 (0.6,1.1)	1.3 (1.0,1.8)
Middle	1.4* (1.1,1.8)	1.5* (1.1,2.2)	1.0 (0.8,1.4)	1.2 (0.9,1.7)
Richer	1.7*** (1.3,2.2)	1.9*** (1.3,2.7)	1.1 (0.8,1.4)	1.5* (1.1,2.0)
Richest	2.1*** (1.5,2.9)	3.1*** (2.1,4.6)	1.3 (1.0,1.8)	2.4*** (1.7,3.3)
Place of Residence				
Urban	Ref.	Ref.	Ref.	Ref.
Rural	0.8 (0.7,1.0)	0.8 (0.6,1.0)	1.0 (0.8,1.3)	0.9 (0.7,1.2)
Division				
Barisal	Ref.	Ref.	Ref.	Ref.
Chittagong	0.8 (0.6,1.2)	0.7 (0.5,1.2)	0.8 (0.6,1.1)	0.7 (0.5,1.0)
Dhaka	1.1(0.8,1.5)	1.2 (0.8,1.9)	1.2 (0.8,1.7)	1.2 (0.8,1.7)
Khulna	1.3 (0.9,1.9)	1.6* (1.1,2.5)	1.2 (0.9,1.7)	1.3 (0.9,1.9)
Rajshahi	0.9 (0.7,1.3)	1.2 (0.7,1.8)	0.9 (0.6,1.3)	1.1 (0.7,1.6)
Rangpur	1.7** (1.2,2.4)	2.4*** (1.5,3.7)	1.4 (1.0,2.0)	1.7** (1.2,2.6)
Sylhet	0.7(0.5,1.1)	0.8 (0.5,1.3)	0.8 (0.5,1.1)	0.7 (0.5,1.0)

AOR: Adjusted odds ratio; BDHS: Bangladesh Demographic and Health Survey; CI: Confidence interval; *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.
NA: Not applicable; these variables were not investigated into multivariable models as the significance level was >0.2 in crude analysis.

hypertension with the greater odds among males (AOR: 6.1; 95% CI: 4.6–8.3) and females (AOR: 7.7; 95% CI: 5.7–10.3) of ≥65 years. Diabetes and overweight/obesity also had significantly greater odds of hypertension among both sexes. Although secondary or above education level was a correlate of hypertension among males, education level had no significant association with hypertension among females ($p > 0.05$). Wealth status also had increased adjusted odds in both sexes. Living in Rangpur division had positive association with hypertension among both males (AOR: 2.4; 95% CI: 1.5–3.7) and females (AOR:1.7; 95% CI: 1.2–2.6). Khulna division had a significant relationship with hypertension only among males (AOR: 1.6; 95% CI: 1.1–2.5).

4. Discussion

After stratifying the prevalence and determinants of prehypertension and hypertension according to sex in Bangladesh, we found association of several factors with increased prevalence and odds of hypertension among both sexes. The common associated factors for hypertension were older age, overweight/obesity, diabetes, and division of residence; education level was a significant factor for males only. There was no consistent pattern in prevalence or odds of prehypertension across sexes. The differences in distributions (i.e., prevalence) of risk factors could contribute to the overall difference in prevalence of hypertension between males and females. To our knowledge, this is the first population-based study that has stratified prevalence and associated factors of these conditions by sex in Bangladesh.

Considering the total study population, the proportion of people with at least 'above-normal' level of blood pressure (i.e., prehypertension plus hypertension) was nearly 47%, 60%, and 54% for males, females, and both sexes, respectively. This higher proportion indicates that more than half of people above 35 years of age are at a higher risk of complications of raised blood pressure and may need to receive more public health awareness of this health issue to avert negative consequences associated with these conditions. The prevalence is also similar compared to other reports from South Asian countries [12,32–35]. The prevalence of hypertension was higher among females compared to males across all background characteristics, which is due to differences in distributions of these characteristics (Table 1). These differences in prevalence indicate that females need more awareness to control hypertension or prevent its complications.

The difference in the association between education level and prehypertension/hypertension observed in this study was not found by the studies that investigated the determinants of these conditions without stratification [18–20]. Harshfield et al. found an association of education level with the co-existence of hypertension and hyperglycemia after stratifying by sex [36]. Education was also found to be associated with awareness and control related to hypertension and other non-communicable diseases [17,21,33]. Furthermore, education level is related to wealth status, which may explain its mechanism of association with elevated blood pressure among males [37,38]. More research is needed to explain this association.

There were significant relationships between respondents' wealth status and blood pressure levels among both sexes. Wealth status was associated with prehypertension among males only. This finding is consistent with other studies that investigated prevalence and risk factors of hypertension in Bangladesh [18–20] as well as other developing countries [12,33,35]. However, this is contrary to the findings from high-income countries, where people with lower socioeconomic conditions have an increased likelihood of hypertension [5,39,40]. People with higher socioeconomic status in LMICs follow more sedentary

lifestyles. Additionally, people from a higher socioeconomic status may be able to purchase more consumable resources than people from a lower socioeconomic status[18,20,41]. As a result, higher income individuals tend to consume more food, which ultimately leads to diabetes and overweight, and puts them at an increased risk of hypertension [18]. Increasing awareness and adoption of a healthier lifestyle are essential for this high-risk group.

Males and females in the older age groups had significantly greater prevalence and odds of prehypertension and hypertension. Older adults have increased risks of diabetes, dyslipidemia, overweight, and other co-existing diseases [36,41,42]. Due to the ongoing demographic transition in Bangladesh, the proportion of people with advancing age are more likely to increase [10]. Age is not a modifiable risk factor; however, early diagnosis, management, and control may minimize future complications [24]. Regular screening could be recommended for older people of both sexes for early diagnosis.

Overweight/obese individuals of both sexes were more likely to be prehypertensive and hypertensive. Males and females with diabetes also had increased odds of hypertension. Earlier studies that investigated the risk factors for diabetes, hypertension, and overweight/obesity in Bangladesh found similar associated factors including wealth status, education level, and older age [36,41,43]. Awareness and control programs addressing hypertension, diabetes, and overweight/obesity in Bangladesh together would be more beneficial than a separate program addressing each disease.

Like earlier reports, several divisions were associated with increased prevalence and likelihood of hypertension among both sexes [19,36,41]. Rangpur had the highest prevalence of hypertension compared to the other divisions among males and females. Although division of residence was not a significant correlate for prehypertension among females, it had a significant association among males living in Rangpur. Along with Rangpur, Khulna was associated with increased hypertension among males. Socioeconomic inequality among divisions could be the main contributing factor for these differences [18,19,41]; however, this finding illustrates the need for further investigation to identify reasons for the higher prevalence of hypertension in these divisions. Additionally, it is important to prioritize the higher prevalence regions with preventive programs.

Consistent with previous studies that investigated risk factors without stratification by sex, this study did not observe any relationship between rural-urban place of residence and hypertension or prehypertension, though the prevalence of hypertension was higher in urban areas than the rural areas among both males and females [36,41]. This might be because education level, wealth status, diabetes, and overweight/obesity are main contributing factors instead of a person's place of residence; individuals with these conditions are more concentrated in urban areas in Bangladesh in contrast to rural regions. Only Chowdhury and colleagues found a weak association between hypertension status and the place of residence [41], though other studies which analyzed BDHS 2011 did not observe this association(18–20,36).

As previously explained, it was essential to learn if these factors differentially affect males and females. Although significance levels for the characteristics varied across males and females for prehypertension, the associated factors were similar for hypertension across both sexes. The significant relationship between hypertension and many shared factors between males and females suggests that a common prevention and control strategy could be helpful for both sexes. Considering the negative impacts of hypertension, implementing a national awareness and control program is essential. Due to resource limitation and other health priorities, implementing such a program could be challenging for countries like Bangladesh [44].

Covering rural and urban areas of all divisions made the sample nationally representative. Large sample size, high response rate, and standardized validated methods were other major strengths that helped to estimate prevalence and risk factors precisely [10]. The limitations of this article also warrant discussions. Blood pressure was measured in a single day; longitudinal measurement is recommended to confirm the diagnosis of prehypertension and hypertension[3,23,45]. The BDHS 2011 was a cross-sectional dataset; the associations may not be causal due to lack of temporal evidence [10]. As several variables were not collected in this survey, studied variables were not adjusted for several confounders or known risk factors for elevated blood pressure levels including genetic factors, smoking, lifestyle, and dietary habits (e.g., salt intake) [3,27]. Although this survey was the most recent one to date, it was conducted nearly seven years before the analysis, and the reported prevalence or associated factors may have changed over time [10]. In addition, the BDHS 2011 only included participants aged 35 years or older, that may overestimate the overall results. However, these limitations highlight the importance of further investigation of unexamined risk factors associated with development of prehypertension and hypertension in Bangladesh.

5. Conclusion

This study showed that several characteristics have higher prevalence and likelihood of hypertension among both males and females including older age, diabetes, overweight/obesity, wealth status, and division of residence in Bangladesh. Although education level was significant only among males, and risk factors for prehypertension had no consistent pattern across sexes, our results indicate that males and females with some common characteristics are at a greater risk of complications resulting from elevated blood pressure levels. Due to commonality of the risk factors for hypertension, a common prevention and control strategy may be helpful; however, implementing such a strategy would be challenging. Males and females with these characteristics should adopt healthier lifestyles to minimize complications of hypertension, as well as modification of programmatic and system-level efforts are needed to account for high-risk populations. Health, economic, and social systems must also support individuals to have healthier lifestyles. Early diagnosis, prevention and treatment of hypertension are crucial. Furthermore, more surveys are required to better understand the current prevalence and associated factors of hypertension in Bangladesh.

Funding

No funding was received for this study.

Availability of data and material

Data may be made available upon request to the ICF International, Maryland, USA.

Authors' contributions

GMAK did the literature review and conceptualized the study, GMAK and AS prepared the first draft of the manuscript, GMAK and AS performed statistical analyses, AC, KS, and VB did the critical review of the manuscript. All authors read and approved the final manuscript.

Authors' information

No additional information to disclose.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable for this study.

Acknowledgment

We are thankful to the ICF International, Rockville, Maryland, USA for giving us the permission to use the data. The authors are also thankful to all survey participants for their time.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ijchy.2019.100006.

References

[1] M.H. Forouzanfar, P. Liu, G.A. Roth, M. Ng, S. Biryukov, L. Marczak, et al., Global burden of hypertension and systolic blood pressure of at least 110 to 115 mm Hg, 1990-2015, J. Am. Med. Assoc. 317 (2) (2017 10) 165–182.
[2] 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 388 (10053) (2016 08) 1603–1658.
[3] P.K. Whelton, R.M. Carey, W.S. Aronow, D.E. Casey, K.J. Collins, C. Dennison Himmelfarb, 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 (2017 Nov 13). HYP.0000000000000065.
[4] M.M. Ibrahim, A. Damasceno, Hypertension in developing countries, Lancet 380 (9841) (2012 Aug 11) 611–619.
[5] K.S. Dorans, K.T. Mills, Y. Liu, J. He, Trends in prevalence and control of hypertension according to the 2017 American College of cardiology/American heart association (ACC/AHA) guideline, Journal of the American Heart Association 7 (11) (2018 Jun), e008888.
[6] K.T. Mills, J.D. Bundy, T.N. Kelly, J.E. Reed, P.M. Kearney, K. Reynolds, et al., Global disparities of hypertension prevalence and Control Clinical perspective: a systematic analysis of population-based studies from 90 countries, Circulation 134 (6) (2016 Aug 9) 441–450.
[7] M.H. Forouzanfar, L. Alexander, H.R. Anderson, V.F. Bachman, S. Biryukov, M. Brauer, et al., Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013, Lancet 386 (10010) (2015 Dec) 2287–2323.
[8] NCD Risk Factor Collaboration (NCD-RisC), Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults, Lancet 390 (10113) (2017 Dec 16) 2627–2642.
[9] B. Zhou, J. Bentham, M. Di Cesare, H. Bixby, G. Danaei, M.J. Cowan, et al., Worldwide trends in blood pressure from 1975 to 2015: a pooled analysis of 1479 population-based measurement studies with 19·1 million participants, Lancet 389 (10064) (2017 Jan) 37–55.
[10] National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International, Bangladesh Demographic and Health Survey 2011 [Internet], 2013. Dhaka, Bangladesh, [cited 2018 Jun 19]. Available from: https://dhsprogram.com/pubs/pdf/fr265/fr265.pdf.
[11] G.M.A. Kibria, K. Swasey, A. Choudhury, V. Burrowes, K.A. Stafford, S.M.I. Uddin, et al., The new 2017 ACC/AHA guideline for classification of hypertension: changes in prevalence of hypertension among adults in Bangladesh, J. Hum. Hypertens. 32 (2018 Jun 13).
[12] S. Ghosh, S. Mukhopadhyay, A. Barik, Sex differences in the risk profile of hypertension: a cross-sectional study, BMJ Open 6 (7) (2016 Jul), e010085.
[13] B. Everett, A. Zajacova, Gender differences in hypertension and hypertension awareness among young adults, Biodemogr. Soc. Biol. 61 (1) (2015 Jan 2) 1–17.
[14] K.E. Agho, U.L. Osuagwu, O.K. Ezeh, P.R. Ghimire, S. Chitekwe, F.A. Ogbo, Gender differences in factors associated with prehypertension and hypertension in Nepal: a nationwide survey. Uthman O, editor, PLoS One 13 (9) (2018 Sep 13), e0203278.
[15] P. August, S. Oparil, Hypertension in women, J. Clin. Endocrinol. Metab. 84 (6) (1999 Jun) 1862–1866.
[16] M. Doumas, V. Papademetriou, C. Faselis, P. Kokkinos, Gender differences in hypertension: myths and reality, Curr. Hypertens. Rep. 15 (4) (2013 Aug) 321–330.
[17] M. Rahman, G. Williams, A. Al Mamun, Gender differences in hypertension awareness, antihypertensive use and blood pressure control in Bangladeshi adults: findings from a national cross-sectional survey, J. Health Population and Nutrition [Internet] 36 (1) (2017 Dec) [cited 2018 Sep 24];Available from: http://jhpn.biomedcentral.com/articles/10.1186/s41043-017-0101-5.
[18] M. Rahman, M.M. Zaman, J.Y. Islam, J. Chowdhury, H.N. Ahsan, R. Rahman, et al., Prevalence, treatment patterns, and risk factors of hypertension and pre-hypertension among Bangladeshi adults, J. Hum. Hypertens. 32 (2017 Dec 11).
[19] M.I. Tareque, A. Koshio, A.D. Tiedt, T. Hasegawa, Are the rates of hypertension and diabetes higher in people from lower socioeconomic status in Bangladesh? Results from a nationally representative survey, PLoS One 10 (5) (2015), e0127954.
[20] M. Rahman, H. SE, M.J. Islam, M.G. Mostofa, K.A. Saadat, Association of socioeconomic status with diagnosis, treatment and control of hypertension in diabetic hypertensive individuals in Bangladesh: a population-based cross-sectional study, JRSM Open 6 (10) (2015 Oct), 205427041560811.
[21] T. Biswas, M.S. Islam, N. Linton, L.B. Rawal, Socio-economic inequality of chronic non-communicable diseases in Bangladesh, in: M. Rahman (Ed.), PLoS One, 11(11), 2016 Nov 30, e0167140.
[22] A.K.M.M. Islam, A.A.S. Majumder, Hypertension in Bangladesh: a review, Indian Heart J. 64 (3) (2012 May) 319–323.
[23] A.V. Chobanian, G.L. Bakris, H.R. Black, W.C. Cushman, L.A. Green, J.L. Izzo, et al., The seventh report of the Joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report, J. Am. Med. Assoc. 289 (19) (2003 May 21) 2560–2572.
[24] J. Chalmers, S. MacMahon, G. Mancia, J. Whitworth, L. Beilin, L. Hansson, 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. 21 (5–6) (1999 Aug) 1009–1060.
[25] B. Williams, G. Mancia, W. Spiering, E. Agabiti Rosei, M. Azizi, M. Burnier, et al., 2018 ESC/ESH Guidelines for the management of arterial hypertension, Eur. Heart J. 39 (33) (2018 Sep 1) 3021–3104.
[26] K.A. Nerenberg, K.B. Zarnke, A.A. Leung, K. Dasgupta, S. Butalia, K. McBrien, et al., Hypertension Canada's 2018 guidelines for diagnosis, risk assessment, prevention, and treatment of hypertension in adults and children, Can. J. Cardiol. 34 (5) (2018 May) 506–525.
[27] G.M. Gabb, A.A. Mangoni, C.S. Anderson, D. Cowley, J.S. Dowden, J. Golledge, et al., Guideline for the diagnosis and management of hypertension in adults — 2016, Med. J. Aust. 205 (2) (2016 Jul 18) 85–89.
[28] World Health Organization. Body Mass Index Classification [Internet]. [cited 2018 Apr 27]. Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html.
[29] World Health Organization, Definition and Diagnosis of Diabetes Mellitus and Intermediate Hyperglycemia: Report of a WHO/IDF Consultation, 2006. Geneva, Switzerland.
[30] G. Maldonado, S. Greenland, Simulation study of confounder-selection strategies, Am. J. Epidemiol. 138 (11) (1993 Dec 1) 923–936.
[31] Stata Corporation, Stata 14.0, College Station,Texas USA, 2015.
[32] G.M.A. Kibria, K. Swasey, A. Kc, M. Mirbolouk, M.N. Sakib, A. Sharmeen, et al., Estimated change in prevalence of hypertension in Nepal following application of the 2017 ACC/AHA guideline, JAMA Network Open 1 (3) (2018 Jul 13), e180606.
[33] G.M.A. Kibria, K. Swasey, A. Sharmeen, M.N. Sakib, V. Burrowes, Prevalence and associated factors of pre-hypertension and hypertension in Nepal: analysis of the Nepal demographic and health survey 2016, Health Science Reports (2018 Aug 10) e83.
[34] R.R. Dhungana, A.R. Pandey, B. Bista, S. Joshi, S. Devkota, Prevalence and associated factors of hypertension: a community-based cross-sectional study in municipalities of kathmandu, Nepal, Int. J. Hypertens. 2016 (2016) 1–10.
[35] M. Hasan, I. Sutradhar, T. Akter, R. Das Gupta, H. Joshi, M.R. Haider, et al., Prevalence and determinants of hypertension among adult population in Nepal: data from Nepal Demographic and Health Survey 2016. Li Y, editor, PLoS One 13 (5) (2018 May 31), e0198028.
[36] E. Harshfield, R. Chowdhury, M.N. Harhay, H. Bergquist, M.O. Harhay, Association of hypertension and hyperglycaemia with socioeconomic contexts in resource-poor settings: the Bangladesh Demographic and Health Survey, Int. J. Epidemiol. 44 (5) (2015 Oct) 1625–1636.
[37] L. Bloomberg, J. Meyers, M.T. Braverman, The importance of social interaction: a new perspective on social epidemiology, social risk factors, and health, Health Educ. Q. 21 (4) (1994 Dec) 447–463.
[38] S.T. Yabiku, S. Schlabach, Social change and the relationships between education and employment, Popul. Res. Pol. Rev. 28 (4) (2009 Aug) 533–549.
[39] U.K.A. Sampson, T.L. Edwards, E. Jahangir, H. Munro, M. Wariboko, M.G. Wassef, 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, Circulation: Cardiovascular Quality and Outcomes 7 (1) (2014 Jan 1) 33–54.
[40] S. Scholes, M. Bajekal, H. Love, N. Hawkins, R. Raine, M. O'Flaherty, 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 [Internet] 12 (1) (2012 Dec) [cited 2018 Jun 20] Available from: http://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-12-129.
[41] M.A.B. Chowdhury, M.J. Uddin, M.R. Haque, B. Ibrahimou, Hypertension among adults in Bangladesh: evidence from a national cross-sectional survey, BMC Cardiovasc. Disord. [Internet] 16 (1) (2016 Dec) [cited 2018 May 18];Available from: http://www.biomedcentral.com/1471-2261/16/22.
[42] M.A.B. Chowdhury, M.M. Adnan, M.Z. Hassan, Trends, prevalence and risk factors of overweight and obesity among women of reproductive age in Bangladesh: a pooled analysis of five national cross-sectional surveys, BMJ Open 8 (7) (2018 Jul), e018468.
[43] T. Biswas, S.P. Garnett, S. Pervin, L.B. Rawal, The prevalence of underweight, overweight and obesity in Bangladeshi adults: data from a national survey, in: R.A. Nugent (Ed.), PLoS One, 12(5), 2017 May 16, e0177395.
[44] T. Biswas, S. Pervin, M.I.A. Tanim, L. Niessen, A. Islam, Bangladesh policy on prevention and control of non-communicable diseases: a policy analysis, BMC Public Health 17 (1) (2017 19) 582.
[45] P. Muntner, R.M. Carey, S. Gidding, D.W. Jones, S.J. Taler, J.T. Wright, et al., Potential U.S. Population impact of the 2017 American College of cardiology/American heart association high blood pressure guideline, Circulation 137 (2017 Nov 13).