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Prevalence of and factors associated with hypertension in Bangladesh: A multilevel and generalized structural equation modeling

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Abstract:	Introduction: Bangladesh is experiencing a rise in the prevalence of hypertension, and the current study aimed to explore the prevalence of and factors associated with hypertension in Bangladesh. Methodology: We utilized the latest (2017-18) Bangladesh Demographic and Health Survey (BDHS) data. We used the chi-square test, multilevel logistic regression analyses, and structural equation modeling (SEM) to identify the factors associated with hypertension and its pathways in Bangladesh. Findings: The prevalence of hypertension was 27% (95% CI: 26.7-28.2%), significantly differing across all characteristics except place of residence. Multilevel logistic regression model found that the likelihood of hypertension was significantly higher among ages 35-44 (aOR= 2.58, P<0.001), 45-54 (aOR= 4.35, P<0.001), 55-64 (aOR= 6.80, P<0.001), and 65+ (aOR= 9.42, P<0.001). Being females (aOR= 1.16, P<0.05), from richer (aOR= 1.25, P<0.05) richest household (aOR= 1.40, P<0.001), formerly married (aOR= 1.36, P<0.05) had also q higher prevalence of hypertension than males, poor household, and never married, respectively. Overweight (aOR= 4.40, P<0.001)) and diabetic (aOR= 1.71, P<0.001) and participants from Dhaka (aOR= 0.75, P<0.01) and Mymensingh division (aOR= 0.78, P<0.05) had a lower hypertension than others. SEM shows that age (β= 0.11) and BMI (β= 0.13) were significant predictors of hypertension, where sex (female) (β= 0.17) and wealth (β= 0.11) worked as enhancers of BMI. Age (β=0.036) and BMI (β=0.046) tended to increase diabetes, resulting in hypertension β=0.11). Conclusion: This study has used a multilevel model and SEM to present the probable causative factors affecting hypertension. Policy planners can consider the article's findings as necessary, as it will help them understand the potential causative factors (e.g., age, sex, and BMI) affecting hypertension in Bangladesh and prioritize actions.
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Cover Letter

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November 04, 2023

Editor
PLOS One

Subject: Submission of an original research article titled **"Prevalence of and factors associated with hypertension in Bangladesh: A multilevel and generalized structural equation modeling"**.

Dear Editor,

Greetings! I hope you are safe and fine. I am submitting our co-authored research paper, **"Prevalence of and factors associated with hypertension in Bangladesh: A multilevel and generalized structural equation modeling"** to be considered for *PLOS One*.

We believe that the results we present would be a good fit for the readers of your journal, and I hope you will consider evaluating the manuscript. I have attached the full manuscript. In this paper, we have shown the prevalence of, and factors associated with hypertension in Bangladesh utilizing the data from the latest Bangladesh Demographic and Health Survey (BDHS), 2017-18. We employed the chi-square test, multilevel logistic regression analyses, and structural equation modeling to identify the factors associated with hypertension and its pathways in Bangladesh.

Policy planners of Bangladesh and other developing countries may need to consider the findings of the article as necessary, as it will help them to understand the probable causative factors (e.g., age, sex, and BMI) affecting hypertension in Bangladesh and prioritize actions.

We believe these results fit well with *PLOS One*'s aim of publishing works that will directly impact the policy related to population redistribution in Bangladesh.

Thank you very much.

With regards,

Yours Sincerely,

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Prevalence of and factors associated with hypertension in Bangladesh: A multilevel and generalized structural equation modeling.

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Abstract

Introduction: Bangladesh is experiencing a rise in the prevalence of hypertension, and the current study aimed to explore the prevalence of and factors associated with hypertension in Bangladesh.

Methodology: We utilized the latest (2017-18) Bangladesh Demographic and Health Survey (BDHS) data. We used the chi-square test, multilevel logistic regression analyses, and structural equation modeling (SEM) to identify the factors associated with hypertension and its pathways in Bangladesh.

Findings: The prevalence of hypertension was 27% (95% CI: 26.7-28.2%), significantly differing across all characteristics except place of residence. Multilevel logistic regression model found that the likelihood of hypertension was significantly higher among ages 35-44 (aOR= 2.58, P≤0.001), 45-54 (aOR= 4.35, P≤0.001), 55-64 (aOR= 6.80, P≤0.001), and 65+ (aOR= 9.42, P≤0.001). Being females (aOR= 1.16, P≤0.05), from richer (aOR= 1.25, P≤0.05) richest household (aOR= 1.40, P≤0.001), formerly married (aOR= 1.36, P≤0.05) had also q higher prevalence of hypertension than males, poor household, and never married, respectively. Overweight (aOR= 4.40, P≤0.001)) and diabetic (aOR= 1.71, P≤0.001) and participants from Dhaka (aOR= 0.75, P≤0.01) and Mymensingh division (aOR= 0.78, P≤0.05) had a lower hypertension than others. SEM shows that age (β= 0.11) and BMI (β= 0.13) were significant predictors of hypertension, where sex (female) (β= 0.17) and wealth (β= 0.11) worked as enhancers of BMI. Age (β=0.036) and BMI (β=0.046) tended to increase diabetes, resulting in hypertension β=0.11).

Conclusion: This study has used a multilevel model and SEM to present the probable causative factors affecting hypertension. Policy planners can consider the article's findings as necessary, as it will help them understand the potential causative factors (e.g., age, sex, and BMI) affecting hypertension in Bangladesh and prioritize actions.

Keywords: Hypertension, Bangladesh, factors, determinants, prevalence.

Introduction

Persistently high blood pressure in the systemic arteries is considered hypertension (HTN), which can be clinically diagnosed with the measurement of systolic blood pressure showing a reading of >140mmHg and diastolic blood pressure showing the reading of >90 mmHg for an individual on two different days.[1,2] With almost one in four men and one in five women suffering from hypertension (HTN) globally, it has been considered one of the leading 'preventable' causes of 'premature' death and the highest prevalent risk factor for cardiovascular diseases (CVD).[3] It has been explored globally that with the progress of economic development, HTN tends to affect people with higher socioeconomic status, but at the later stage, the prevalence of HTN increases in the lower socioeconomic regions, and they also bear the more significant consequences.[2] The last 40 years have experienced almost a doubling in the number of people having high blood pressure, and the increase has primarily taken place in low and middle-income countries, and on the contrary, the cases are found to be declining in the higher-income countries around the world.[4,5]

Like other low and middle-income countries, Bangladesh is also experiencing a rise in the prevalence of hypertension [6] at a point of time when the epidemiological shift of causes of death from infectious diseases and nutritional deficiencies to chronic diseases is prominently visible [7] here. It can be attributed to the rapid pace of urbanization, the rise in life expectancy, dietary habits, and lifestyle changes.[8,9] HTN is one of the most preventable risk factors of non-communicable chronic diseases and can be tackled with simple health promotion and preventive approaches. Yet, it is persistently posing a significant impact on Bangladesh's health systems and socioeconomic conditions.[10] With around 25% prevalence of hypertension [11] among all populations, it bears great public health importance, especially in the context when hypertension often remains undiagnosed, especially among poor and low-educated persons in Bangladesh.[12]

Though biomedical and genetic factors are highly responsible for hypertension, socioeconomic and behavioral factors have been proven to be causative of hypertension worldwide. [13–18] Studies have presented that socioeconomic statuses, such as occupation and education, have a

significant impact on hypertension [13,19,20]. Furthermore, physical inactivity, consumption of tobacco and alcohol, unhealthy diet, excessive salt consumption, low intake of fruits and vegetables, being overweight and obese have been identified as malleable risk factors and significant risk factors for hypertension. [3,21–24]. Moreover, all those factors and different levels and magnitude of the effect of individuals in other countries. The mechanism by which these factors affect hypertension differs substantially among males and females. [25] Therefore, it is essential to investigate the factors associated with hypertension in a country. For that reason, multilevel (to address country-specific heterogeneity) and structural equational modeling (SEM) using logistic regression will provide the best approximation of the causative factors of the disease.

Various recent studies have focused on different aspects of hypertension in Bangladesh with an overall emphasis [10,13,26], specific focus on rural areas [7,27,28], urban areas [8], particular groups of professionals [29], and age cohort [30–32], trend analysis.[33] Previous studies also focused on investigating factors from nationally representative cross-sectional surveys. However, none of the studies have focused on establishing potential causation with SEM. In this context, the current study aimed to explore the prevalence and factors associated with hypertension in Bangladesh using multilevel modeling and the pathways using an SEM. This research will not only provide differentials of hypertension but also find out the predictors of hypertension and which predictors have the highest effect. In addition, it will also provide the pathway in which the predictors function and affect the prevalence of hypertension in the country. On that account, this study can be food for thoughts for the policy planners in the current context when the prevalence of hypertension is persistently increasing within the overall disease burden of Bangladesh.

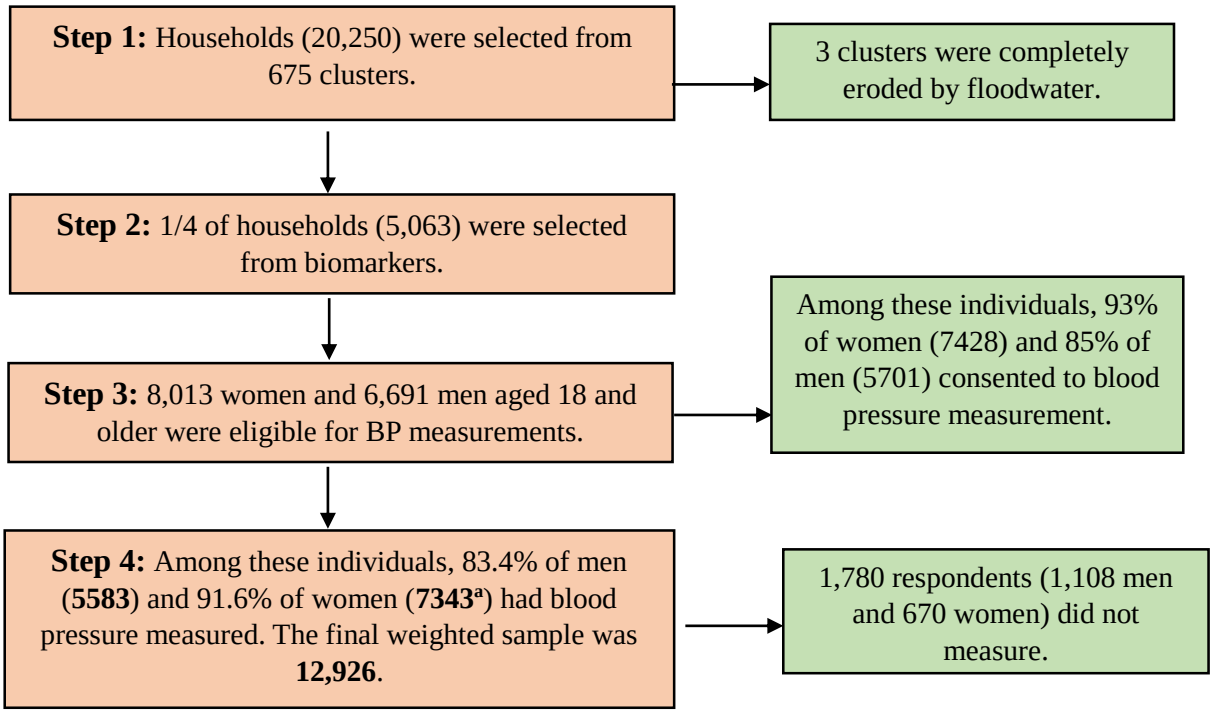
Methodology

Source of Data and Inclusion Criteria

We utilized the data from the latest *Bangladesh Demographic and Health Survey (BDHS), 2017-18*, the seventh of its type undertaken in Bangladesh as a part of an international program of measures DHS.[6] The sample for the BDHS is nationally representative, and a detailed

methodology will be found elsewhere in the report.[6] The BDHS follows two-stage stratified sampling with a response rate of 98.8%. In the first stage, 675 enumeration areas (EAs) or primary sampling units (PSUs) were chosen with probability relative to EA size: 425 in rural and 250 in urban areas. The survey was successfully conducted in 672 clusters after eliminating three clusters (one urban and two rural) that were utterly eroded by floodwater. Blood pressure (BP) measures testing were collected from men and women aged 18 years and above in the subsample of 1/4 of the households (**Fig 1**).

Fig 1. Flowchart of selecting sample size of the study



a. The sample size in the published report was 7341.

Outcome variable

The LIFE SOURCE® UA-767 Plus BP monitor was used to measure blood pressure in the BDHS survey.[6] Three measurements of blood pressure (measured in millimeters of mercury [mmHg]) were taken during the survey interview, with an interval of at least 5 minutes between measurements, using a digital oscillometric blood pressure measuring device with automatic upper-arm inflation and an automatic pressure release. The average of the second and third measurements was used to classify individuals with hypertension. Respondents whose blood pressure fell into two categories based on their average systolic and average diastolic levels were

classified according to the highest blood pressure category in which they fell on either of the two measures. If the third blood pressure measurement was missing, the second measurement was considered the average. The first was considered the average if the second and third measurements were missing. Individuals were classified as having hypertension if, at the time of the survey, they had an average systolic blood pressure (SBP) level of 140 mmHg or above, they had an average diastolic blood pressure (DBP) level of 90 mmHg or above, or they were currently taking antihypertensive medication. Individuals were classified as having hypertension if, at the time of the survey, they had an average systolic blood pressure (SBP) level of 140 mmHg or above, they had an average diastolic blood pressure (DBP) level of 90 mmHg or above, or they were currently taking antihypertensive medication.

Predictor

We selected covariates based on the existing literature [34–38] and the availability of variables in the dataset.[6] Demographic (including age, sex, and marital status), socioeconomic, health, and community factors were potential determinants of hypertension. We included education (categorized as no education, primary incomplete, primary complete, secondary incomplete, and secondary complete and higher), wealth index, and employment status as socioeconomic factors. The wealth index, used to assess the household's socioeconomic status, was constructed from data on household possessions using the principal component analysis and divided into five groups (poorest, poorer, middle, richer, and richest) based on overall asset ownership.

Health factors include diabetes and body mass index (BMI). If individuals had a fasting blood glucose (FBG) corresponding to level of 7 mmol/L or more at the time of the interview or currently taking prescribed medicine for their high blood glucose or diabetes were considered as having raised blood glucose or diabetes. BMI is categorized as underweight (BMI <18.5), normal (BMI 18.5-24.9), and overweight/obese (BMI >24.9). Administrative division (8 divisions: Barisal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, and Sylhet) and place of residence (whether residing in the urban or rural area) are two major community/spatial factors we included in the study. We measured community socioeconomic status by averaging individual-level education and household-level wealth index in the EA/ PSU.

Statistical Analysis

We performed both bivariate, multiple, and multivariate analyses. For bivariate analysis, we used the chi-square test. We used variance inflator factor (VIF) to scrutinize multicollinearity among the explanatory variables (mean VIF: 2.04, range 1.0 to 4.49). Since BDHS data are hierarchical, for example, individuals are nested within households, and households are nested within clusters, the use of flat models might underestimate standard errors of the estimates, which consequently could affect the decision on the null hypothesis. Individuals within the same cluster might be more like each other than the rest of the country, which violates the assumption of flat models: independence of observations and equal variance across the clusters. Therefore, we have used multilevel (two-level random effect model) logistic regression analyses to identify the factors associated with hypertension in Bangladesh by adjusting cluster variance. Five models were analyzed: an empty/null model, a model containing demographic factors, a model containing socioeconomic factors, a model containing health-related factors, and a model containing community factors. All the analyses were carried out considering the complex sampling of the survey. This study also used generalized structural equational modeling (GSEM) to present the possible pathways through which socioeconomic and other factors affect hypertension.

Results

Characteristics of the participants

Demographic, socioeconomic, health, and community-level related characteristics are presented in **Table 1**. Many participants (44.8%) were between 18 and 34 years. Around 57% were female and 80% were currently married. About 26% of the respondents had no institutional education, and 60.5% were employed. More than 57% of the participants had normal BMIs, while 9.5% had diabetes. Around 73% of the respondents were from rural areas, and 23.9% were from Dhaka.

Table 1. Characteristics of the participants and prevalence of hypertension, 2017-18

Characteristics of the respondents	Sample characteristics (%)	Prevalence of hypertension (95% CI)	P-value	Number
Demographic factors				
Age			≤0.001	
18-34	44.8	12.8 (11.9, 13.6)		5787

35-44	20.0	28.4 (26.7, 30.2)		2585
45-54	14.0	38.5 (36.2, 40.7)		1815
55-64	11.3	46.8 (44.2, 49.3)		1454
65+	9.9	54.5 (51.7, 57.2)		1285
Sex			0.005	
Male	43.2	26.2 (25.0, 27.4)		5583
Female	56.8	28.4 (27.4, 29.5)		7343
Marital status			≤0.001	
Never married	9.8	11.1 (9.3, 12.8)		1266
Currently married	80.5	26.7 (25.9, 27.6)		10405
Formerly/ever married	9.7	50.2 (47.4, 52.9)		1255
Socioeconomic factors				
Highest educational level			≤0.001	
No education	25.8	35.9 (34.3, 37.6)		3332
Primary incomplete	19.8	26.8 (25.1, 28.5)		2564
Primary complete	10.0	27.1 (24.7, 29.5)		1290
Secondary incomplete	25.7	22.8 (21.4, 24.2)		3325
Secondary complete or higher	18.7	23.1 (21.5, 24.8)		2415
Currently working			≤0.001	
No	39.5	31.0 (29.7, 32.2)		5108
Yes	60.5	25.2 (24.2, 26.2)		7817
Household wealth index			≤0.001	
Poorest	19.0	23.7 (22.1, 25.4)		2459
Poorer	19.6	25.2 (23.5, 26.9)		2534
Middle	20.4	26.8 (25.0, 28.4)		2635
Richer	19.8	28.2 (26.5, 30.0)		2560
Richest	21.2	32.9 (31.2, 34.7)		2738
Health factors				
Body mass index (BMI) [a]			≤0.001	
Underweight	16.9	17.6 (16.0, 19.2)		2182
Normal	57.9	23.9 (22.9, 24.8)		7483
Overweight	25.2	42.3 (40.6, 44.0)		3261
Have Diabetes [a]			≤0.001	
No	90.5	25.5 (24.7, 26.3)		11697
Yes	9.5	46.5 (43.7, 49.3)		1229
Spatial/Community factors				
Place of residence			0.112	
Urban	27.4	28.5 (27.0, 30.0)		3542
Rural	72.6	27.1 (26.2, 28.0)		9383
Division (region)			≤0.001	
Barisal	5.6	32.6 (29.2, 36.1)		718
Chittagong	17.3	29.8 (27.9, 31.7)		2237
Dhaka	23.9	23.6 (22.1, 25.1)		3095
Khulna	12.3	29.9 (27.6, 32.1)		1586
Mymensingh	8.3	23.6 (21.0, 26.1)		1067

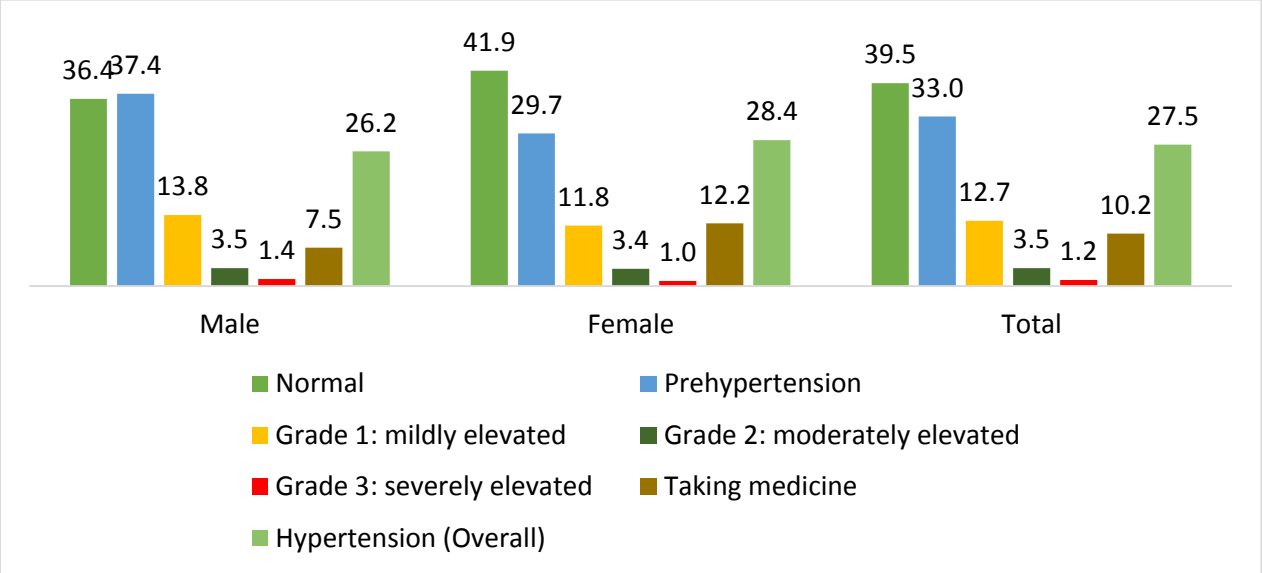
Rajshahi	14.2	27.5 (25.4, 29.5)		1829
Rangpur	12.0	30.5 (28.2, 32.8)		1552
Sylhet	6.5	26.2 (23.2, 29.1)		840
Total	**100.0**	**27.5 (26.7, 28.2)**		**12926**

a. The missing information was replaced as 'normal BMI' or 'no diabetes' so as not to lose the final sample. As a result, the rate of diabetes and BMI were slightly different (sensitivity analysis did not produce any diverging result). A 95% CI=95% Confidence interval.

Prevalence and differentials of hypotension

Table 1 summarizes the prevalence and differentials of hypertension in Bangladesh. The prevalence of hypertension is 27%, with a 95% CI of 26.7 and 28.2. The prevalence of hypertension was significantly different than people without hypertension across all characteristics (p = 0.005 to <0.001; Table 1) except place of residence (p=0.112). However, **Fig 2** illustrates the sex-specific prevalence of different hypotension. Around 40% of the participants had no hypertension, whereas 33% had prehypertension, followed by grade 1 (12.7%), grade 2 (3.5%), and grade 3 hypertension (1.2%). Moreover, 10.2% of the participants were taking medicine during the survey. All kinds of hypertension (except normal and prehypertension) were significantly higher among females than males.

Fig 2. Sex-specific prevalence of different types of hypertension among Bangladeshi adults



Factors associated with hypertension

Five random effect multilevel logistic regression models were analyzed to identify the factors associated with hypertension (**Table 2**). Model five (the final model) had a lower random

intercept, Akaike Information Criteria (AIC), and Bayesian Information Criteria (BIC) value, resulting in a better model. Compared to age 18-34, the likelihood of hypertension was significantly higher among ages 35-44 (aOR= 2.58, P≤0.001), 45-54 (aOR= 4.35, P≤0.001), 55-64 (aOR= 6.80, P≤0.001), and 65+ (aOR= 9.42, P≤0.001). Females (aOR= 1.16, P≤0.05) and formerly married (aOR= 1.36, P≤0.05) had significantly higher prevalence of hypertension than males and never married, respectively. Being richer (aOR= 1.25, P≤0.05), richest (aOR= 1.40, P≤0.001), normal (aOR= 1.79, P≤0.001), and overweight in BMI (aOR= 4.40, P≤0.001), and diabetic (aOR= 1.71, P≤0.001) had higher hypertension than others. The participants from Dhaka (aOR= 0.75, P≤0.01) and Mymensingh division (aOR= 0.78, P≤0.05) had lower hypertension, while the participants of Rangpur division (aOR= 1.23, P≤0.05) has higher hypertension than Sylhet division.

Table 1: Factors associated with hypertension using hierarchical multilevel logistic regression.

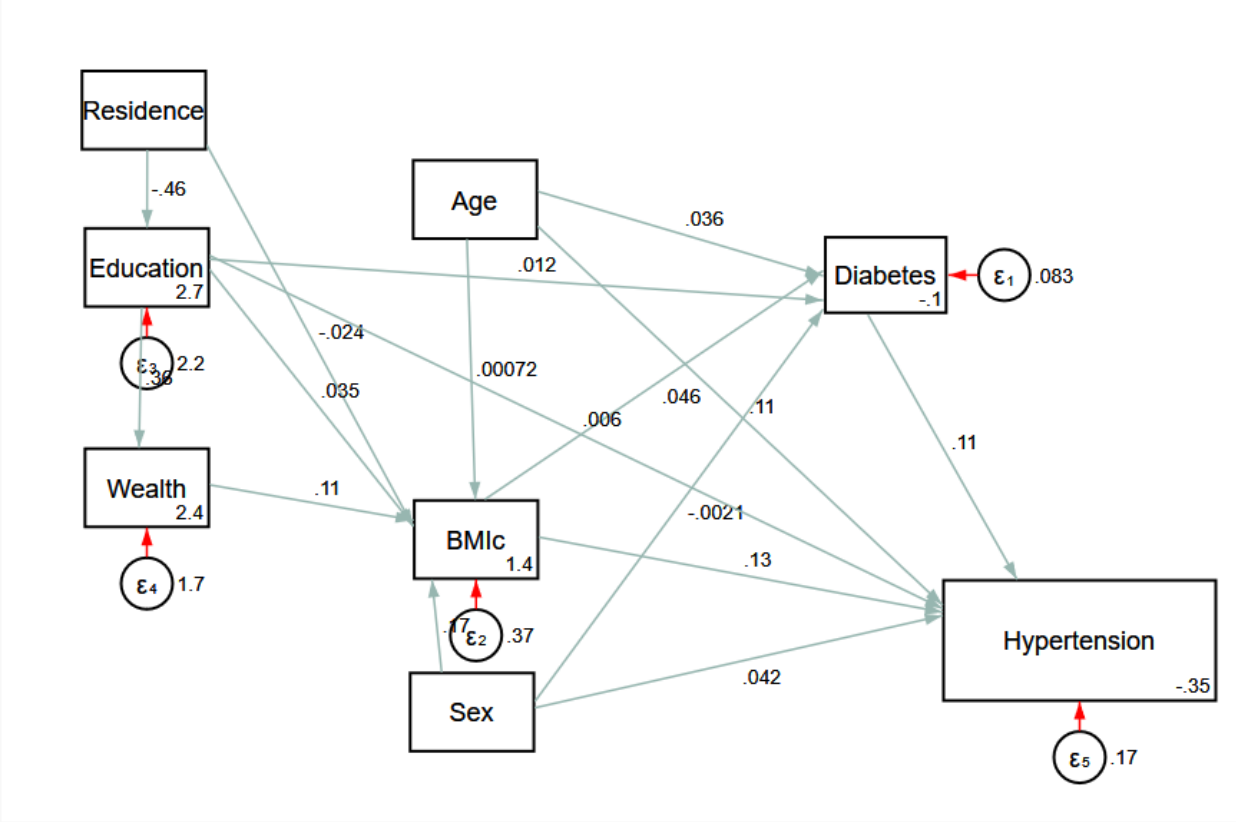
	Null model	Model 2, aOR (SE)	Model 3, aOR (SE)	Model 4, aOR (SE)	Model 5, aOR (SE)
Demographic factors					
Age					
18-34					
35-44		2.79 [0.20]***	3.04 [0.23]***	2.64 [0.20]***	2.58 [0.20]***
45-54		4.40 [0.36]***	4.95 [0.43]***	4.51 [0.39]***	4.35 [0.38]***
55-64		6.21 [0.48]***	7.07 [0.60]***	7.16 [0.62]***	6.80 [0.60]***
65+		8.43 [0.76]***	9.52 [0.96]***	9.96 [1.05]***	9.42 [1.00]***
Sex					
Male					
Female		1.37 [0.07]***	1.33 [0.08]***	1.18 [0.08]**	1.16 [0.08]*
Marital status					
Never married					
Currently married		1.13 [0.12]	1.20 [0.13]	0.96 [0.11]	0.96 [0.11]
Formerly/ever married		1.44 [0.19]**	1.61 [0.22]***	1.38 [0.19]*	1.36 [0.19]*
Socioeconomic factors					
Highest educational level					
No education			0.77 [0.06]***	0.92 [0.08]	1.03 [0.09]
Primary incomplete			0.88 [0.07]	0.98 [0.08]	1.06 [0.09]
Primary complete			0.99 [0.10]	1.07 [0.11]	1.15 [0.12]
Secondary incomplete			1.03 [0.08]	1.06 [0.08]	1.12 [0.09]
Secondary complete+					
Currently working					
No			1.12 [0.07]*	1.07 [0.07]	1.09 [0.07]
Yes					
Household wealth index					
Poorest					

Poorer			1.10 [0.10]	1.02 [0.09]	1.06 [0.10]
Middle			1.19 [0.10]*	1.03 [0.09]	1.12 [0.10]
Richer			1.39 [0.12]***	1.10 [0.10]	1.25 [0.12]*
Richest			1.71 [0.14]***	1.11 [0.10]	1.40 [0.14]***
Health factors					
Body mass index (BMI)					
Underweight					
Normal				1.83 [0.12]***	1.79 [0.12]***
Overweight				4.46 [0.38]***	4.40 [0.37]***
Have Diabetes					
No					
Yes				1.68 [0.13]***	1.71 [0.13]***
Spatial/Community factors					
Place of residence					
Urban					1.13 [0.08]
Rural					
Division (region)					
Barisal					1.14 [0.14]
Chittagong					1.00 [0.11]
Dhaka					0.75 [0.08]**
Khulna					0.97 [0.11]
Mymensingh					0.78 [0.09]*
Rajshahi					1.01 [0.12]
Rangpur					1.23 [0.14]*
Sylhet					
Community wealth index					1.05 [0.02]***
Community level education					1.00 [0.01]***
Constant	0.37 [0.01]***	0.10 [0.01]***	0.07 [0.01]***	0.05 [0.01]***	0.03 [0.01]***
Random intercept	0.12 [0.03]	0.16 [0.03]	0.14 [.03]	0.14 [0.03]	0.11 [0.03]

*=p≤0.05, **=p≤0.01, ***=p≤0.001; aOR: adjusted odds ratio; SE-standard error in the Brackets.

The structural factors (pathways) affecting the likelihood of hypertension are depicted in **Fig 3**. The age (β= 0.11) and BMI (β= 0.13) were significant predictors of hypertension, where sex (female) (β= 0.17) and wealth (β= 0.11) worked as enhancers of BMI. Age (β=0.036) and BMI (β=0.046) tended to increase diabetes, resulting in hypertension β=0.11).

Fig 3. A path diagram of factors affecting the likelihood of hypertension in Bangladesh using generalized structural equation modeling (GSEM)



Note: Residence (urban vs rural); education, wealth, age, BMI as continuous; Sex (Female vs Male), Diabetes (Yes vs No), and Hypertension (Yes vs No).

Discussion

World Health Organization has estimated that around 1.28 billion adults of 30-79 years worldwide have hypertension and most of them have been living in low- and middle-income countries.[3] It is the dominant pervasive risk factor for cardiovascular disease associated with stroke, microvascular disease, myocardial infarction, heart failure, renal failure, and early death. In that context, this study aimed to explore the proportion and factors associated with hypertension in Bangladesh. The study found that the prevalence of hypertension is 27%. The prevalence of hypertension was significantly different than people without hypertension across all characteristics except place of residence. All kinds of hypertension (except normal and prehypertension) were markedly higher among females than males. Besides age, sex, marital status, highest educational level, currently working, household wealth index, BMI, diabetes status, and division have been identified as differentials of hypertension in Bangladesh. Similarly, age, sex, and racial identity were addressed as differentials of hypertension in the United

States.[39] On the other hand, education, sex, household wealth, income, dietary factors, and stress were identified as differentials of hypertension in studies of Nepal, China, and India.[40–42]

The multilevel logistic regression models suggest that, compared to age 18-34, the likelihood of hypertension was significantly higher among ages 35-44. The high prevalence of blood pressure with advanced age is predominantly linked with structural changes in the arteries, especially with large artery stiffness.[43,44] Advanced age significantly influences the cardiovascular system and, in particular, the large arteries.[43,44] Age-related increases in blood pressure have been observed in almost every population.[14,44–46] A study of 4800 Saudi Arabian hypertension patients presented that higher age is linked with a significant surge in the prevalence of hypertension.[45] Further, another study of the American female population presented that older age enervated the linkage between hypertension and the other four risk factors.[46]

Females, compared to males, were found to have a significantly higher prevalence of hypertension. However, studies around the world presented a complicated relationship between sex and hypertension prevalence. A study including respondents from 13 countries found that the prevalence of prehypertension was 40% among males and 33% among females.[47] Moreover, age has been reported to have an impact on gender differentials of hypertension. A study in the USA suggested that men have a higher incidence of hypertension until the age of 45, males and females aged 46 to 64 years were reported to have similar rates of hypertension incidence, and women have a higher incidence after 65 years old.[48] Other studies also presented that men are more likely to have hypertension than female until the sixth decade of life.[49]

Our result suggests that those formerly married had a significantly higher prevalence of hypertension than never married. However, some studies presented contradictory picture with these findings. A cohort study of 1889 Iranian individuals concluded that being never married in men was associated with a higher risk of hypertension in comparison with married.[50] On the

other hand, widowed Iranian women presented a lower risk of hypertension than married ones.[50] A study on African Americans investigated that individuals who remain single are associated with an increased risk of developing hypertension.[51] Among Chinese individuals, persons who previously had partners had a higher OR of hypertension compared to married and unmarried, and younger formerly married are more prone to risk than older ones.[52]

Our findings presented that respondents from wealthy households had higher hypertension than others. These findings are consistent with the common perception that the prevalence of NCDs in the least developing countries (LCDs) is more common among the wealthiest group.[20] However, a study of six low and middle-income countries presented that, in India and Ghana, more affluent groups have a higher prevalence of hypertension. At the same time, there is a below-average prevalence among the richest in China and the Russian Federation.[20] Lastly, South Africa does not indicate a gradient, and Mexico offers high rates for poor people.[20]

Furthermore, our findings presented that overweight BMI (has a higher prevalence of hypertension than any other group. Obesity and overweight affect hypertension in pathways like metabolic, endothelial, and vascular dysfunction, dietary factors, sodium retention, proteinuria, glomerular hyperfiltration, and maladaptive immune and inflammatory responses.[53] Overweight and obesity proved to function as an attributable risk factor for hypertension in various studies around the world.[54–57] Finally, our findings suggested that diabetic individuals have higher hypertension than others. This finding is in line with other findings about the relationship between diabetics and hypertension, where one empirical study suggested that the risk of hypertension is almost twice as prevalent in people with diabetes as in non-diabetics, and it has been suggested that much of the morbidity and mortality with diabetes is interlinked with hypertension and often coincident with diabetes.[16,58,59]

Strengths and limitations

This study is one of the few studies in the country that have applied multilevel logistic regression model to connect the risk factors associated with hypertension. It has also presented a pathway

by which this factor causes hypertension for individuals in the country using SEM. For that reason, this will provide probable causation of the diseases (though causality is poor in cross-sectional studies), which will help policy planners set priorities. However, multilevel modeling has its limitations. A significant difficulty in public health to apply multilevel models is the threat to the internal validity of inferences posed by confounding in observational studies. [60] Moreover, public health applications of multilevel models, particularly those using nonexperimental data, could be substantially improved by integrating counterfactual thinking into framing research questions [60]. Due to the lack of important observed variables (e.g., smoking status and physical activity), complete causal pathways cannot be established here.

Conclusion

Hypertension is a major cause of death worldwide.[3] It is evident from the findings that Bangladesh has a considerable amount of hypertension patients (the same level of hypertension prevalence as the WHO African region).[3] The population has many risk factors for this disease. As the country has experienced a fertility transition, the number of aging populations is increasing day by day, which is one of the most attributable risk factors of the disease. This study used structural equational modeling to present the causative factors affecting hypertension using nationally representative cross-sectional data. In conclusion, it can be argued that policy planners of Bangladesh and other developing countries like it need to consider the findings of the article as necessary, as it will help them to understand the probable causative factors (e.g., age, sex, and BMI) affecting hypertension in Bangladesh and prioritize actions.

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