Received: 5 July 2019 | Revised: 27 September 2019 | Accepted: 7 October 2019

DOI: 10.1002/hsr2.141

RESEARCH ARTICLE

WILEY Health Science Reports Open Access

Association between height and hypertension in the adult Nepalese population: Findings from a nationally representative survey

Rajat Das Gupta[1,2,3] | **Shams Shabab Haider[2]** | **Mohammad Rashidul Hashan[4]** | **Muhammad Aziz Rahman[5,6]** | **Malabika Sarker[1,2,7]**

[1] Centre of Excellence for Non-Communicable Diseases and Nutrition, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh

[2] Centre of Excellence for Science of Implementation and Scale-Up, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh

[3] Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia, South Carolina, United States of America

[4] Infectious Diseases Division, International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), Dhaka, Bangladesh

[5] School of Nursing and Healthcare Professions, Federation University, Victoria, Australia

[6] School of Nursing and Midwifery, La Trobe University, Heidelberg, Australia

[7] Institute of Public Health, Heidelberg University, Heidelberg, Germany

Correspondence
Rajat Das Gupta, Senior Research Associate, BRAC James P Grant School of Public Health, BRAC University, 5th Floor (Level-6), icddr,b Building, 68 Shahid Tajuddin Ahmed Sharani, Mohakhali, Dhaka-1212, Bangladesh.
Email: rajat89.dasgupta@gmail.com

Abstract

Background and aims: The burden of hypertension is increasing in Nepal. Different studies have evaluated the relationship between height and blood pressure in different regions, with mixed results. The relationship between height and hypertension has not yet been explored in the Nepalese context. Given this knowledge gap, this study aims to determine the relationship between height and hypertension among Nepalese adults (aged ≥18 years).

Methods: This study utilized the dataset from the Nepal Demographic and Health Survey (NDHS) 2016. Hypertension was defined as systolic blood pressure- 140 mmHg and/or a diastolic blood pressure ≥ 90 mmHg. Height, measured in centimeters (cm), was analyzed as a continuous variable. Based on previous evidence, the following covariates were considered: age, sex, presence of overweight or obesity, educational status, household wealth status, and place, province, and ecological zone of residence. Multilevel multivariable logistic regression was done to evaluate the association between height and hypertension. Both crude odds ratio (COR) and adjusted odds ratio (AOR) are reported, along with a 95% confidence interval (CI). Sample weight of NDHS was adjusted during analysis.

Results: Among 13 393 weighted individuals over the age of 18 years, the prevalence of hypertension in Nepal was found to be 21.1% (95% CI, 19.9%-22.4%). In the final multivariable model, after adjusting for relevant covariates, it was found that height was inversely associated with hypertension. For a Nepalese adult, the odds of hypertension decreased by 10% with each 10-cm increase in height (AOR 0.9; 95% CI 0.8-0.9; P = 0.003).

Conclusion: Awareness should be raised among people with low stature for prevention of hypertension. Longitudinal studies are recommended to include genetic and social/environmental determinants of stature in the analyses.

KEYWORDS

hypertension, noncommunicable diseases, Nepal

1 | INTRODUCTION

Hypertension—or high blood pressure—epitomizes a global public health concern due to its association with a number of noncommunicable diseases (NCDs), including coronary artery disease, stroke, heart failure, and chronic kidney disease.[1] According to the Global Burden of Disease Study 2017 report, hypertension is the single largest contributor to the global burden of disease and mortality, with a death toll of 10.4 million per year.[2] Hypertension is also responsible for the loss of 20.9% disability-adjusted life years (DALYs) worldwide.[3] In total, a quarter of the world's adult population is affected by hypertension.[4]

A variety of lifestyle, behavioral, anthropometric, and genetic factors can affect one's probability of developing hypertension.[5,6] In particular, the seminal research of Gertler et al in the 1950s first demonstrated an inverse association between stature and coronary heart disease.[7] Further investigations have shown that this relationship extends to blood pressure in general.[8-12] However, mixed results have been reported regarding the strength of the relationship between height and blood pressure.[8-13] A sample survey of NCDs in urban Nigerian adults found no association between height and hypertension.[13] On the other hand, nationally representative surveys from the United States, which included results from Caucasian-, African-, and Mexican-American adults,[8] as well as from Bangladesh,[9] Indonesia,[10] and China[11] have shown an inverse association between these variables. A study of adults in Brazil showed a statistically significant inverse association among women only.[12]

High blood pressure is a leading risk factor for a variety of NCDs throughout the developing world.[14] In particular, low- and middle-income countries (LMICs) shoulder over 80% of the global burden.[3] Nepal, like other LMICs that have previously focused on communicable disease services, is now on the threshold of an epidemiological transition due to the increasing burden of NCDs, including hypertension.[15] As of 2016, around 20% of all Nepalese adults were diagnosed with hypertension.[16,17] The prevalence of long-term complications due to hypertension (ie, cardiovascular diseases) is also increasing day-by-day.[18]

There are some studies that have explored the prevalence of hypertension as well as its associated risk factors in a variety of contexts throughout Nepal.[17,19,20] Similarly, there are also studies that have measured the height of respondents in order to examine the relation between BMI and hypertension.[16,17] However, there are no studies that have exclusively examined the association between height and hypertension in the specific context of Nepal. Given the inconsistent evidence regarding the link between height and hypertension, there remains a relevant knowledge gap. Utilization of the nationally representative Nepal Demographic and Health Survey (NDHS) 2016 will provide the clearest picture regarding whether the height of the Nepalese population is associated with their probability of developing hypertension. Determination of height as a risk factor can help policymakers develop more effective and nuanced health promotion campaigns in the future. Therefore, the objective of this study is to assess the association between height and diagnosis of hypertension among adults aged ≥18 years in Nepal.

2 | METHODS

2.1 | Data source and study design

This study is based on a secondary analysis of the Nepal Demographic and Health Survey (NDHS) 2016. NDHS 2016 was a nationally representative survey aimed at generating the latest data on the basic demographic and health indicators of Nepal. NEW ERA implemented the survey in Nepal between June 2016 and January 2017, supervised by the Nepalese Ministry of Health (MoH). The detailed methodology and data collection procedure of NDHS 2016 have previously been published.[21]

NDHS 2016 followed a stratified cluster sampling of households to collect data. In the rural area, a two-staged sampling technique was used. After selecting primary sampling units (PSUs) using the probability proportional to size (PPS) method, a fixed amount (n = 30) of households were selected from each of the PSUs. In the urban area, a three-staged sampling method was followed. At first, PSUs were selected, and then enumeration areas (EAs) were selected from each PSU. Then, households were selected from the EAs. In the end, data were collected from 11 490 households (5520 urban households and 5970 rural households).

2.2 | Outcome of interest

The outcome of interest in this study was hypertension among the adult Nepalese population (≥18 years). Blood pressure (BP) was measured by UA-767F/FAC (A&D Medical) BP monitors. The cuff size (small, medium, or large) was used according to the arm circumference of the respondent. For each individual, BP was measured three times, with each measurement separated by at least 5 min. The average of the second and third measurements was used to calculate the BP level of the respondents.[21] Hypertension was defined according to the Joint National Committee Seven (JNC7) guideline. Respondents with a systolic blood pressure (SBP) of ≥140 mmHg and/or a diastolic blood pressure (DBP) of ≥90 mmHg were considered to be hypertensive. If the study participant was taking antihypertensive medications during the time of the survey, then he/she was also classified as hypertensive, irrespective of BP level.[22]

2.3 | Independent variables

The main explanatory variable of interest was height of the respondents, which was considered as a continuous variable, measured in centimeters (cm). Based on previous literature, the considered covariates were age,[16,17] sex,[16,17] marital status,[16,17] educational attainment,[16,17] household wealth index,[16,17] body mass index (BMI),[16,17] and place,[23] province,[16,17] and ecological region of residence.[16,17] Age was categorized for comparability to previous studies. The definition of each category is listed in Table 1.

2.4 | Statistical analysis

First, a descriptive analysis was conducted, and the findings are presented in frequencies and percentages. Household wealth index was calculated based on principal component analysis of selected assets, ie, construction material type used for roofing and flooring, type of water source, sanitation facilities, electricity, and other belongings (eg, television and bicycle).[20,24,25] During the descriptive analyses, sample weight of NDHS 2016 was used. Next, simple and multivariable multilevel logistic regression analyses were conducted to determine factors associated with hypertension. The multilevel logistic regression analysis was conducted considering the complex hierarchical structure of DHS data[26-29] as well as adjusting for the cluster sampling design.[30] In the final multivariable logistic regression model, a variable was considered significant if the yielded *P* value was <0.05. To check for multicollinearity among the covariates, variance inflation factor (VIF) was used; no significant multicollinearity was found. Both crude odds ratio (COR) and adjusted odds ratio (AOR) with 95% confidence interval (CI) are reported. All the statistical analyses were done in Stata 13.0 (College Station, Texas, USA).[31]

2.5 | Ethical considerations

The study protocol, as well as the tools of NDHS 2016, were reviewed and approved by the ethical review board of the Nepal Research Council and ICF International.[20] Before collecting data, informed verbal consent was taken from the heads of the household as well as from the respondents.[20] The corresponding author (RDG) applied for the dataset to the DHS program by submitting the study protocol. DHS program approved the application and provided the dataset.

3 | RESULTS

The overall sociodemographic characteristics of the respondents are presented in Table 2. A total of 13 393 weighted adult individuals (>18 years of age) were included in the final analyses. The majority of the study participants was female (58.0%), had received no formal education (41.6%), and were from the urban area (61.2%). Among the 13 393 weighted samples, 2827 were classified as hypertensive (21.1%; 95% CI, 19.9%-22.4%).

Table 3 shows the results of the logistic regression analyses for the factors evaluated for an association with hypertension. According to the final (adjusted) logistic regression analysis, older age, male sex, overweight or obesity, being in the richest wealth index, and residence in Provinces No. 4 and No. 5 were found to be positively associated

TABLE 1 List of variables considered for the study

Study Variables	Description and Categories
Outcome variable	Blood pressure of the study participants (0 = normal blood pressure; 1 = hypertension)
Explanatory variables	
Age	Age of the study participants in years (0 = 18-29 y; 1 = 30-49 y; 2 = 50-69 y; 3 = ≥70 y)
Sex	Sex of the study participants (0 = female; 1 = male)
Overweight/obesity	Presence of overweight/obesity in the study participants measured by body mass index (BMI) in kilogram (kg)/meter^2 (m^2) [0 = No (BMI < 23 kg/m^2); 1 = Yes (BMI ≥ 23 kg/m^2)]
Education	Education level of the study participants (0 = no formal education; 1 = primary; 2 = secondary; 3 = college or higher)
Household wealth status	Household wealth quintile (0 = poorest; 1 = poorer; 2 = middle; 3 = richer; 4 = richest)
Place of residence	Type of the cluster (0 = urban; 1 = rural)
Province of residence	Province of residence of the respondents (0 = Province 1; 1 = Province 2; 2 = Province 3; 3 = Province 4; 4 = Province 5; 5 = Province 6; 6 = Province 7)
Ecological zone of residence	Topological zone of residence of the respondents in Nepal (0 = mountains; 1 = hills; 2 = the Terai [plain land])
Height	Height of the study participants in centimeter (cm)[a]

[a]Considered as a continuous variable. In the regression model, the unit of height was 10 cm.

TABLE 2 Distribution of the respondents according to blood pressure status, n (%) (N = 13 393)

Characteristics	Overall, N = 13 393		Blood Pressure Status			
			Yes (N = 2827)[a]		No (N = 10 566)[a]	
	n	%	n	%	n	%
Age (in years)						
18-29	4337	32.4	266	6.1	4071	93.9
30-49	5002	37.4	1083	21.7	3919	78.3
50-69	3188	23.8	1101	34.5	2087	65.5
≥70	866	6.5	377	43.5	489	56.5
Sex						
Male	5620	42.0	1429	25.4	4191	74.6
Female	7773	58.0	1398	18.0	6375	82.0
Obese/overweight						
No	8567	64.0	1,342	15.7	7,224	84.3
Yes	4826	36.0	1,485	30.8	3,342	69.2
Education						
No formal education	5572	41.6	1365	24.5	4207	75.5
Primary	2172	16.2	474	21.8	1698	78.2
Secondary	3699	27.6	680	18.4	3019	81.6
Tertiary	1950	14.6	308	15.8	1642	84.2
Household wealth status						
Poorest	2396	17.9	449	18.7	1947	81.3
Poorer	2594	19.4	548	21.2	2046	78.8
Middle	2666	19.9	475	17.8	2191	82.2
Richer	2917	21.8	554	19.0	2363	81.0
Richest	2820	21.1	801	28.4	2019	71.6
Place of residence						
Urban	8191	61.2	1831	22.4	6360	77.6
Rural	5202	38.8	996	19.2	4206	80.8
Provinces						
Province 1	2365	17.7	475	20.1	1889	79.9
Province 2	2748	20.5	440	16.0	2308	84.0
Province 3	2933	21.9	732	24.9	2202	75.1
Province 4	1380	10.3	398	28.8	982	71.2
Province 5	2184	16.3	509	23.3	1675	76.7
Province 6	674	5.0	109	16.1	565	83.9
Province 7	1109	8.3	164	14.8	945	85.2
Ecological region						
Mountains	856	6.4	155	18.1	701	81.9
Hills	5895	44.0	1426	24.2	4469	75.8
The Terai	6642	49.6	1246	18.8	5396	81.2
Height, cm						
Median (IQR)	155	150-185	155	149-162	155	150-162

[a]Row percentage.

TABLE 3 Results of logistic regression analyses to compare crude and adjusted ORs for the factors associated with hypertension

Traits	COR (95% CI)		*P* Value	AOR (95% CI)		*P* Value
Age (in years)						
18-29	Ref.			Ref.		
30-49	4.4	(3.8-5.1)	<0.001	3.7	(3.1-4.3)	<0.001
50-69	8.9	(7.6-10.3)	<0.001	8.0	(6.8-9.6)	<0.001
≥70	14.6	(12.0-17.8)	<0.001	14.2	(11.3-17.8)	<0.001
Sex						
Female	Ref.			Ref.		
Male	1.6	(1.5-1.8)	<0.001	1.7	(1.5-2.0)	<0.001
Overweight/obesity						
No	Ref.			Ref.		
Yes	2.7	(2.5-3.0)	<0.001	2.4	(2.1-2.7)	<0.001
Education						
No formal education	Ref.			Ref.		
Primary	0.8	(0.7-0.9)	<0.001	1.1	(0.9-1.2)	0.40
Secondary	0.5	(0.5-0.6)	<0.001	1.0	(0.9-1.2)	0.60
College or higher	0.4	(0.4-0.5)	<0.001	1.0	(0.8-1.2)	>0.99
Household wealth status						
Poorest	Ref.			Ref.		
Poorer	1.1	(1.0-1.3)	0.07	1.2	(1.0-1.4)	0.06
Middle	1.0	(0.9-1.2)	0.80	1.1	(0.9-1.3)	0.2
Richer	1.1	(1.0-1.3)	0.10	1.2	(1.0-1.4)	0.2
Richest	1.7	(1.4-2.0)	<0.001	1.5	(1.1-1.8)	0.002
Place of residence						
Urban	1.2	(1.0-1.4)	0.01	1.1	(1.0-1.3)	0.2
Rural	Ref.			Ref.		
Provinces						
Province 1	Ref.			Ref.		
Province 2	0.8	(0.6-1.0)	0.04	0.9	(0.7-1.2)	0.8
Province 3	1.3	(1.0-1.7)	0.02	1.1	(0.8-1.4)	0.7
Province 4	1.6	(1.3-2.0)	<0.001	1.4	(1.0-1.8)	0.03
Province 5	1.2	(0.9-1.5)	0.2	1.3	(1.1-1.7)	0.03
Province 6	0.8	(0.6-1.0)	0.06	1.0	(0.7-1.3)	>0.90
Province 7	0.7	(0.5-0.9)	<0.001	0.8	(0.6-1.1)	0.20
Ecological region						
Mountains	Ref.			Ref.		
Hills	1.6	(1.2-2.1)	<.001	1.2	(0.9-1.6)	0.20
The Terai	1.2	(0.9-1.6)	0.20	1.0	(0.7-1.4)	0.80
Height (per 10 cm)	1.0	(0.9-1.0)	0.70	0.9	(0.8-0.9)	0.003

Note. The final model was adjusted for age, sex, presence of overweight/obesity, education, household wealth status, place of residence, province of residence, ecological region and height (in 10 cm).

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; COR, crude odds ratio.

with hypertension ($P < 0.05$). In the final multivariable model, after adjusting for age; sex; presence of overweight or obesity; educational status; household wealth status; and place, province, and ecological zone of residence, it was found that height was inversely associated with hypertension: For a Nepalese adult, the odds of hypertension decreased 10% with each 10-cm increase in height (AOR 0.9; 95% CI 0.8-0.9; $P = 0.003$).

4 | DISCUSSION

This study aimed to investigate the association between stature and hypertension in the adult Nepalese population. Utilizing a nationally representative sample, this study found an inverse association between height and hypertension in the adult Nepalese population. This is, to the best of our knowledge, the first nationally representative study done in the Nepalese setting that specifically investigated the association between stature and hypertension.

Besides height, the findings of the study reiterated some of the factors known to be associated with hypertension in various populations: older age,[32] male sex,[32] higher socioeconomic status,[33] and overweight and obesity.[34] The study also found a higher likelihood of hypertension among residents of Province No. 4 (officially known as Gandaki Pradesh) and Province No. 5, which is consistent with previous studies.[16,17,22] Public health promotion programs should focus on raising awareness about hypertension among these groups.

The findings of our study are consistent with a similar study from Bangladesh. Hoque et al (2014) found an almost 30% reduction in the odds of hypertension in the group whose height was in the fourth quartile compared to those in the first quartile.[10] Also, Song et al (2016) found an association between height and reduced SBP, pulse pressure, and prevalence of hypertension in the Chinese population aged 37 to 94 years.[12] Moving away from the Asian setting, a similar phenomenon was also observed in Latin America. Data from Colombia, using a prospective cohort study, found that shorter stature in the elderly population was associated with hypertension.[35] Studies done in Brazil have also suggested this inverse association between height and hypertension.[13,36] Schooling et al. (2007) demonstrated that the association between height and elevated blood pressure is not clear until adjusting for the potential confounder of BMI.[37] In the present study, we also adjusted for the effect of BMI in the final model and found a statistically significant inverse association between height and hypertension. Possible reasons for the varied findings of previous studies, including that done in Nigeria, which found no association between height and hypertension, may be related to differences in sample size and target group.[13] For example, the previously mentioned study included only civil servants, which may not be generalizable to the whole population.[13] A study with a nationally representative sample in the Nigerian context can settle this issue.

There are several explanations that could be put forward as to why height may be inversely associated with hypertension. Genetic factors that influence growth may be associated with hypertension. Anatomically, the coronary vessel diameter increases with height, which reduces the risk of atherosclerosis.[38-40] Other factors inversely associated with proper childhood growth (ie, inadequate infant and toddler feeding, smoking habits of the parents, poor socioeconomic status, among others) are also directly associated with hypertension and subsequent cardiovascular disease risk in adulthood.[12,41-43] This study did not have data on these factors, which limited our capability for analysis. Longitudinal studies should be carried out in the South Asian setting to determine the effects of maternal and early child nutrition on the occurrence of hypertension in adult life. Another important aspect is that adult height is nonmodifiable. It was found that most of the stunting occurs before the age of 2 years (often beginning in utero) and catch-up in linear growth is limited beyond this age.[44] Furthermore, evidence indicates that short adult height in low- and middle-income countries (LMICs) is largely driven by environmental conditions (including adequate nutrition and resources, history of infectious disease, and socioeconomic condition). As a result, short adult height might be situated in the causal pathway, between environmental conditions (exposure) and hypertension (outcome).[43] It is, thus, important for public health promotion programs to continue their efforts against malnutrition and stunting.

The strength of this study is that it utilized a nationally representative sample to investigate the association between height and hypertension. The findings of this study are generalizable to the target population in Nepal. Furthermore, NDHS 2016 utilized validated questionnaires and calibrated tools to collect data, which limits the probability of measurement error. The main limitation of the study, on the other hand, is that due to the cross-sectional nature of the survey, the temporal relationship between the outcome (hypertension) and explanatory variable (height) could not be established. As a result, we cannot establish a causal association between height and hypertension. Data on other potential confounders, including family history of hypertension[45], dietary habit,[46] physical activity pattern,[47] history of diabetes mellitus,[48] and tobacco and alcohol use,[49] which are known to affect hypertension, were not collected by the NDHS 2016.[10] As such, we could not adjust for those confounders during the analysis.

5 | CONCLUSIONS

The high prevalence of hypertension is a public health problem in Nepal. While addressing known risk factors, NCDs prevention programs in Nepal should also focus on raising awareness among individuals with low stature for the prevention of hypertension. Further longitudinal studies are recommended to include genetic and social/environmental determinants of stature in the analysis.

ACKNOWLEDGEMENTS

The authors acknowledge the contributions of the Demographic and Health Surveys (DHS) program for providing access to the dataset.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

AUTHOR CONTRIBUTIONS

Conceptualization: Rajat Das Gupta, Malabika Sarker
Data Curation: Rajat Das Gupta, Shams Shabab Haider, Mohammad Rashidul Hashan
Formal Analysis: Rajat Das Gupta, Shams Shabab Haider
Investigation: Rajat Das Gupta, Mohammad Rashidul Hashan, Muhammad Aziz Rahman
Methodology: Rajat Das Gupta, Muhammad Aziz Rahman, Malabika Sarker
Supervision: Muhammad Aziz Rahman, Malabika Sarker
Visualization: Rajat Das Gupta, Shams Shabab Haider, Mohammad Rashidul Hashan, Muhammad Aziz Rahman, Malabika Sarker
Writing – Original Draft Preparation: Rajat Das Gupta, Shams Shabab Haider
Writing – Review & Editing: Rajat Das Gupta, Shams Shabab Haider, Mohammad Rashidul Hashan, Muhammad Aziz Rahman, Malabika Sarker

All authors have read and approved the final version of the manuscript.

The lead author (Rajat Das Gupta) had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

TRANSPARENCY STATEMENT

The lead author (Rajat Das Gupta) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported, that no important aspects of the study have been omitted, and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Demographic and Health Surveys (DHS) Program. Restrictions apply to the availability of these data. Data are available with the permission of the DHS at https://dhsprogram.com/data/dataset/Nepal_Standard-DHS_2016.cfm?flag=0.

ORCID

Rajat Das Gupta https://orcid.org/0000-0002-7680-676X

REFERENCES

1. Lackland DT, Weber MA. Global burden of cardiovascular disease and stroke: hypertension at the core. *Can J Cardiol*. 2015;31(5):569-571. https://doi.org/10.1016/j.cjca.2015.01.009
2. GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2018;392(10159):1923-1994. https://doi.org/10.1016/S0140-6736(18)32225-6
3. GBD 2015 Mortality and Causes of Death Collaborators. 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):1459-1544. https://doi.org/10.1016/S0140-6736(16)31012-1
4. Hedner T, Kjeldsen SE, Narkiewicz K. State of global health–hypertension burden and control. *Blood Press*. 2012;21(Suppl 1):1-2. https://doi.org/10.3109/08037051.2012.704786.
5. Poulter NR, Prabhakaran D, Caulfield M. Hypertension. *Lancet*. 2015;386(9995):801-812. https://doi.org/10.1016/S0140-6736(14)61468-9
6. Carretero OA, Oparil S. Essential hypertension. Part I: definition and etiology. *Circulation*. 2000;101(3):329-335. https://doi.org/10.1161/01.cir.101.3.329
7. Gertler MM, Garn SM, White PD. Young candidates for coronary heart disease. *J Am Med Assoc*. 1951;147(7):621-625.
8. Bourgeois B, Watts K, Thomas DM, et al. Associations between height and blood pressure in the United States population. *Medicine (Baltimore)*. 2017;96(50):e9233. https://doi.org/10.1097/MD.0000000000009233
9. Hoque ME, Khokan MR, Bari W. Impact of stature on non-communicable diseases: evidence based on Bangladesh Demographic and Health Survey, 2011 data. *BMC Public Health*. 2014;14:1007. https://doi.org/10.1186/1471-2458-14-1007
10. Sohn K. The association between height and hypertension in Indonesia. *Econ Hum Biol*. 2017;27(Pt A):74-83. https://doi.org/10.1016/j.ehb.2017.04.007
11. Song L, Shen L, Li H, et al. Height and prevalence of hypertension in a middle-aged and older Chinese population. *Sci Rep*. 2016;6(1):39480. https://doi.org/10.1038/srep39480
12. Sichieri R, Siqueira KS, Pereira RA, Ascherio A. Short stature and hypertension in the city of Rio de Janeiro, Brazil. *Public Health Nutr*. 2000;3(1):77-82.
13. Olatunbosun ST, Bella AF. Relationship between height, glucose intolerance, and hypertension in an urban African black adult population: a case for the "thrifty phenotype" hypothesis? *J Natl Med Assoc*. 2000;92(6):265-268.
14. Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380(9859):2224-2260.
15. Mishra SR, Neupane D, Bhandari PM, Khanal V, Kallestrup P. Burgeoning burden of non-communicable diseases in Nepal: a scoping review. *Global Health*. 2015;11(1):32.
16. Hasan M, Sutradhar I, Akter T, et al. Prevalence and determinants of hypertension among adult population in Nepal: data from Nepal Demographic and Health Survey 2016. *PloS One*. 2018;13(5):e0198028.
17. Kibria GMA, Swasey K, Sharmeen A, Sakib MN, Burrowes V. Prevalence and associated factors of pre-hypertension and hypertension in Nepal: Analysis of the Nepal Demographic and Health Survey 2016. *Health Sci Rep*. 2018;1(10):e83. https://doi.org/10.1002/hsr2.83
18. Vaidya A. Tackling cardiovascular health and disease in Nepal: epidemiology, strategies and implementation. *Heart Asia*. 2011;3(1):87-91. https://doi.org/10.1136/heartasia-2011-010000.
19. Chataut J, Adhikari RK, Sinha NP. The prevalence of and risk factors for hypertension in adults living in central development region of Nepal. *Kathmandu Univ Med J (KUMJ)*. 2011;9(33):13-18.

20. Chataut J, Khanal K, Manandhar K. Prevalence and associated factors of hypertension among adults in rural Nepal: a community based study. *Kathmandu Univ Med J (KUMJ)*. 2015;13(52):346-350.

21. Ministry of Health and Population (MoHP), Nepal New ERA and ICF International Inc. Nepal Demographic and Health Survey 2016. Kathmandu: Ministry of Health and Population; 2017.

22. Chobanian AV, Bakris GL, Black HR, 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):2560-2572. https://doi.org/10.1161/01.HYP.0000075790.33892.AE.

23. Huang Y, Guo P, Karmacharya BM, Seeruttun SR, Xu DR, Hao Y. Prevalence of hypertension and prehypertension in Nepal: a systematic review and meta-analysis. *Glob Health Res Policy*. 2019;4(1):11. https://doi.org/10.1186/s41256-019-0102-6

24. 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):115-132. https://doi.org/10.1353/dem.2001.0003

25. Jolliffe IT, Cadima J. Principal component analysis: a review and recent developments. *Philos Trans A Math Phys Eng Sci*. 2016;374(2065):20150202. https://doi.org/10.1098/rsta.2015.0202

26. Goldstein H. *Multilevel statistical models*. UK: University of Bristol; 2011:1-21.

27. Rabe-Hesketh S. *Skrondal A*. Multilevel and longitudinal modeling using Stata: STATA press; 2008.

28. Hox JJ, Moerbeek M, Van de Schoot R. *Multilevel analysis: techniques and applications*. Routledge; 2017.

29. van Oyen H. Multilevel analysis of survey data. *Int J Public Health*. 2009;54(3):129-130. https://doi.org/10.1007/s00038-009-7075-z

30. Austin PC, Merlo J. Intermediate and advanced topics in multilevel logistic regression analysis. *Stat Med*. 2017;36(20):3257-3277. https://doi.org/10.1002/sim.7336

31. Stata Corporation Limited. *Stata*. 13 StataCorp LP: College Station; 2014.

32. Lee SH, Kim YS, Sunwoo S, Huh BY. A retrospective cohort study on obesity and hypertension risk among Korean adults. *J Korean Med Sci*. 2005;20(2):188-195. https://doi.org/10.3346/jkms.2005.20.2.188

33. Chowdhury MA, Uddin MJ, Haque MR, et al. Hypertension among adults in Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovasc Disord*. 2016;16(1):22. https://doi.org/10.1186/s12872-016-0197-3

34. Babu GR, Murthy GVS, Ana Y, et al. Association of obesity with hypertension and type 2 diabetes mellitus in India: a meta-analysis of observational studies. *World J Diabetes*. 2018;9(1):40-52. https://doi.org/10.4239/wjd.v9.i1.40

35. El-Bikai R, Tahir MR, Tremblay J, et al. Association of age-dependent height and bone mineral density decline with increased arterial stiffness and rate of fractures in hypertensive individuals. *J Hypertens*. 2015;33(4):727-735; discussion 35. https://doi.org/10.1097/HJH.0000000000000475

36. Florencio TT, Ferreira HS, Cavalcante JC, Sawaya AL. Short stature, obesity and arterial hypertension in a very low income population in North-eastern Brazil. *Nutr Metab Cardiovasc Dis*. 2004;14(1):26-33.

37. Schooling CM, Thomas GN, Leung GM, Ho SY, Janus ED, Lam TH. Is height associated with cardiovascular risk in Chinese adults? *Epidemiology*. 2007;18(2):274-278. https://doi.org/10.1097/01.ede.0000254656.02400.27

38. Palmer JR, Rosenberg L, Shapiro S. Stature and the risk of myocardial infarction in women. *Am J Epidemiol*. 1990;132(1):27-32.

39. Lawlor DA, Taylor M, Davey Smith G, Gunnell D, Ebrahim S. Associations of components of adult height with coronary heart disease in postmenopausal women: the British women's heart and health study. *Heart*. 2004;90(7):745-749. https://doi.org/10.1136/hrt.2003.019950

40. Gray L, Davey Smith G, McConnachie A, et al. Parental height in relation to offspring coronary heart disease: examining transgenerational influences on health using the west of Scotland Midspan Family Study. *Int J Epidemiol*. 2012;41(6):1776-1785. https://doi.org/10.1093/ije/dys149

41. de Jonge LL, Harris HR, Rich-Edwards JW, et al. Parental smoking in pregnancy and the risks of adult-onset hypertension. *Hypertension*. 2013;61(2):494-500. https://doi.org/10.1161/HYPERTENSIONAHA.111.200907

42. Gunnell D. Commentary: Can adult anthropometry be used as a 'biomarker' for prenatal and childhood exposures? *Int J Epidemiol*. 2002;31(2):390-394.

43. Perkins JM, Subramanian SV, Davey Smith G, Özaltin E. Adult height, nutrition, and population health. *Nutr Rev*. 2016;74(3):149-165. https://doi.org/10.1093/nutrit/nuv105

44. Onis M, Branca F. Childhood stunting: a global perspective. *Matern Child Nutr*. 2016;12(S1):12-26. https://doi.org/10.1111/mcn.12231

45. Ranasinghe P, Cooray DN, Jayawardena R, Katulanda P. The influence of family history of hypertension on disease prevalence and associated metabolic risk factors among Sri Lankan adults. *BMC Public Health*. 2015;15(1):576. https://doi.org/10.1186/s12889-015-1927-7

46. Ndanuko RN, Tapsell LC, Charlton KE, Neale EP, Batterham MJ. Dietary patterns and blood pressure in adults: a systematic review and meta-analysis of randomized controlled trials. *Adv Nutr*. 2016;7(1):76-89. https://doi.org/10.3945/an.115.009753

47. Hegde SM, Solomon SD. Influence of physical activity on hypertension and cardiac structure and function. *Curr Hypertens Rep*. 2015;17(10):77. https://doi.org/10.1007/s11906-015-0588-3.

48. Lastra G, Syed S, Kurukulasuriya LR, Manrique C, Sowers JR. Type 2 diabetes mellitus and hypertension: an update. *Endocrinol Metab Clin North Am*. 2014;43(1):103-122. https://doi.org/10.1016/j.ecl.2013.09.005.

49. Yu M, Xu CX, Zhu HH, et al. Associations of cigarette smoking and alcohol consumption with metabolic syndrome in a male Chinese population: a cross-sectional study. *J Epidemiol*. 2014;24(5):361-369. https://doi.org/10.2188/jea.je20130112

How to cite this article: Das Gupta R, Haider SS, Hashan MR, Rahman MA, Sarker M. Association between height and hypertension in the adult Nepalese population: Findings from a nationally representative survey. *Health Sci Rep*. 2019;2:e141. https://doi.org/10.1002/hsr2.141