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Original Article

Prevalence and Associated Factors of Hypertension Subtypes Among the Adult Population in Nepal: Evidence from Demographic and Health Survey Data

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ABSTRACT

Objectives: This study aims to determine the prevalence, and associated factors of undiagnosed hypertension [Systolic Diastolic Hypertension (SDH), Isolated Systolic Hypertension (ISH) and Isolated Diastolic Hypertension (IDH)] in the Nepalese adult population.

Methods: Nepal Demographic and Health Survey 2016 data from adults (≥ 18 years) was used in this study. The final weighted sample size was 13,393. Blood pressure (BP) was measured 3 times and the average of the second and third measurement was reported. SDH (systolic BP (SBP) ≥ 140 mmHg and diastolic BP (DBP) ≥ 90 mmHg), ISH (SBP ≥ 140 mmHg and DBP < 90 mmHg), and IDH (SBP < 140 mmHg and DBP ≥ 90 mmHg) were measured. Multilevel logistic regression analyses were conducted to find the association between the independent variables and the covariates.

Results: The prevalence of SDH, IDH and ISH were 8.1%, 7.5%, and 3.3% respectively. The odds of having SDH and ISH increased with old age. However, the odds of having IDH decreased with increasing age. Females has lower odds of having SDH and IDH compared with male participants. Individuals that had been married, resided in Province 4 ($p < 0.05$) or 5 ($p < 0.01$) were statistically significantly associated with having IDH. Being overweight or obese was statistically significantly associated with all 3 HTN subtypes ($p < 0.001$).

Conclusion: The necessary steps should be taken so that public health promotion programs in Nepal may prevent and control undiagnosed hypertension.

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Introduction

Hypertension (HTN) is prevalent worldwide and a major public health problem because of the significant role it plays in the development of cardiovascular and cerebrovascular diseases [1,2]. It is one of the principal modifiable risk factors in both the development of cardiovascular diseases and the resultant morbidity and mortality [3,4]. Globally, about 13% of the total deaths each year is attributable to HTN [5]. In addition, HTN accounts for about 4% of the annual disability-adjusted life-years [6].

The American College of Cardiology and the American Heart Association (2017) defined HTN primarily in 2 stages. Stage 1 is defined as systolic arterial blood pressure [systolic

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BP (SBP)] between 130-139 mmHg and a diastolic arterial BP (DBP) between 80-89 mmHg. Stage 2 is defined as the systolic arterial blood pressure being 140 mmHg or above, and the diastolic arterial BP being 90 mmHg or above [7]. However, in many hypertensive patients, HTN does not manifest its classical form and SBP or DBP may rise independently. In these cases HTN is known as Isolated Systolic Hypertension [ISH (SBP ≥ 140 mmHg and DBP < 90 mmHg)] and Isolated Diastolic Hypertension [IDH (SBP < 140 mmHg and DBP ≥ 90 mmHg)] [8-11]. Increased stiffness or reduced elasticity of the arteries causes ISH, whereas IDH is induced by a rise in arteriole resistance [12]. ISH has been reported to be more common among older adults [13], and associated with an increased risk of developing cardiac failure in the elderly [14]. In the past, IDH did not get as much consideration as the other forms of HTN [11,15], but its importance should not be overlooked [16]. IDH also increases the risk of developing cardiovascular diseases, though the magnitude is lower than with other HTN subtypes [10]. Combined systolic/diastolic HTN (SDH) is also associated with cardiovascular and cerebrovascular diseases [17].

Lowering the mean DBP was reportedly associated with a reduced risk of developing cerebrovascular, and coronary heart diseases by 35-40% and 20-25%, respectively [18,19]. Additionally, a meta-analysis of 61 longitudinal studies showed that people aged 40-69 years had an absolute proportional difference in BPs that was almost the same as an absolute proportional difference in mortality risk due to cardiovascular diseases, up to a certain level of DBP and SBP [20]. In that study, an absolute proportional difference of 20 mmHg in SBP or 10 mmHg in DBP was reported to be associated with a 2-fold absolute proportional difference in the mortality risk due to myocardial infarction or cerebrovascular attacks, wherein SBP and DBP were at least 115 mmHg and 75 mmHg, respectively [20].

The World Health Organization (WHO) reported the alarming burden non-communicable diseases (NCDs) pose worldwide and regionally. More than two-thirds of deaths globally, and about three-quarters of deaths in low- and middle-income countries are attributable to NCDs [5]. Like other parts of the world, South Asian countries have undergone overwhelming demographic and epidemiological transitions. Consequently, there has been a massive shift in cause-specific mortality. The burden of NCDs, such as metabolic disease, cardiovascular disease, and cancers has increased and South Asian people have been more susceptible to these diseases, compared to other ethnic groups [21-23]. Nepal, is currently facing an epidemiological transition due to the increasing burden of NCDs, including HTN [24]. Data from the nationally representative Nepal Demographic and Health Survey (NDHS) in 2016, estimated that 1 in 5 adults in Nepal (aged ≥ 18 years) were hypertensive [25,26]. However, Nepal does not have representative data regarding HTN subtypes and their associated factors. The burden of NCDs in Nepal, along with ISH and IDH, warrant regular reporting of nationally representative data on HTN subtypes, so that preventive modalities can be designed. This study aims to determine the prevalence, distribution, and associated factors of ISH, IDH as well as SDH, in Nepal using the NDHS 2016 data.

Materials and Methods

1. Study design

A secondary analysis of the nationally representative Nepal Demographic and Health Survey (NDHS) 2016 data was conducted. Under the leadership of the Nepal Ministry of Health, NDHS 2016 was administered by NEW ERA from June 2016 to January 2017 [25].

NDHS 2016 utilized the updated sampling frame of the 2011 Nepal National Population and Housing Census. For data collection, stratified cluster sampling of households was followed. In the rural area, a 2-staged stratified sampling technique was followed. At first, 199 primary sampling units (PSUs) were selected based on the probability proportional to size method. At the second stage, households were systematically selected from each PSU. On the other hand, a 3-staged stratified sampling technique was used in the urban area. At the first stage, PSUs (n = 184) were selected by the probability proportional to size method. Then, enumeration areas were randomly selected from each PSU. At the final stage, households were systematically selected from each enumeration area. A total of 11,490 households (5,520 urban households and 5,970 rural households) were included in the final sample. The detailed methodology has been previously published [25].

2. Outcome

Adult Nepalese men and women aged 18 years and above were included in this study. The outcomes of interest of this study were ISH, IDH, and combined systolic/diastolic HTN (SDH). BP was measured using UA-767F/FAC (A&D Medical) BP monitors, and depending on the respondent's arm circumference, small, medium, or large size cuffs were used. For each individual, BP was measured 3 times. After discarding the first measurement, the average of the second and third measurement was reported as the BP of the respondent [25]. In this study, HTN was defined as having an average SBP ≥ 140 mmHg and an average DBP ≥ 90 mmHg. If the individual was taking any antihypertensive medication at the time of the survey irrespective of BP level, he/she was classified as hypertensive [27]. SDH was defined as an average SBP ≥ 140 mmHg and an average DBP ≥ 90 mm Hg [8]. ISH was defined as

an average SBP ≥ 140 mmHg and an average DBP < 90 mmHg, and IDH was defined as an average SBP < 140 mmHg and an average DBP ≥ 90 mm Hg [8].

3. Explanatory variables

Based on literature review, potential explanatory variables that were considered included age (18-29 years, 30-49 years, 50-69 years, ≥ 70 years), gender (male, female), marital status (never married, had been married), highest educational attainment (no formal education, primary education, secondary education and above), household wealth index (poorest, poor, middle, rich, richest), place of residence (urban, rural), province of residence (Province 1, Province 2, Province 3, Province 4, Province 5, Province 6, Province 7), ecological region of residence (the Terai, hills, mountains), and body mass index [BMI, underweight (< 18.5 kg/m^2), normal weight (18.5-23 kg/m^2), overweight/obese (≥ 23 kg/m^2)]. BMI was defined using the Asian cut-off value [28]. Household wealth index was calculated using principal component analysis of selected assets, i.e., construction materials used for the roof and floor of the household, types of water source and sanitation facilities, access to electricity, and other belongings (television, bicycle, etc.) [25,29,30].

4. Statistical analysis

Descriptive analyses of the selected variables (both of the outcome variable and the covariates) were conducted. As all the variables were categorical, they were described using frequencies and percentages. Pearson's Chi-square test was used to observe any differences among the covariates across the BP status of the respondents. The sample weight of the NDHS 2016 was adjusted during the analyses.

Multilevel logistic regression analyses were conducted to find the association between the independent variables (SDH, ISH, and IDH) and the covariates. Multilevel logistic regression was conducted considering the complex hierarchical structure of the DHS dataset [31-33]. At first, bivariate analysis was performed to determine the crude odds ratio (COR) with a 95% confidence interval (CI) with each of the covariates. Those variables, which yielded a pre-determined $p < 0.2$ in the bivariate analyses (which was sufficient to adjust for the additional residual confounding effect), were put into the final multivariate logistic regression model to yield the adjusted odds ratio (AOR) [34]. In the final logistic regression model, those covariates which yielded a $p < 0.05$ were considered statistically significant. Any possible existence of multicolinearity among the covariates was checked using the variance inflation factor. A variance inflation factor value greater than 5 was considered as an indication of multicolinearity [35]. However, no statistically significant multicolinearity was observed. Stata 14.0 was used for data analyses. The guidelines outlined in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement were followed in conducting this study and writing the manuscript (Appendix A) [36].

5. Ethical consideration

NDHS, 2016 received ethical approval from the ethical review board of the Nepal Research Council (approval number: 329/2015) and ICF International (approval no.: ICF IRB FWA00002349). Before data collection, informed consent was given by the respondents.

Results

1. Characteristics of the respondents

A weighted sample of 13,393 Nepalese males and females aged ≥ 18 years of age, were included in the final analyses. Nearly two-thirds (61.2%) of the respondents were from urban areas. About two-fifths (41.6%) of the study participants did not have any formal education. The respondents were almost equally distributed across the 5 wealth quintiles. Almost half of the people (49.6%) were from the Terai region, 44% belonged to the hilly areas, and the rest (6.4%) were from the mountains. More than a third (36%) of the participants were overweight or obese (Table 1).

The weighted prevalence of HTN was 21.1%. The group of young adults (18-29 years of age) had the least prevalence of HTN (6.1%) compared to the other age groups. Around one-fifth (21.7%) of the middle-aged (30-49 years), and about two-thirds (34.5%) of the older adults (50-69 years) had HTN. The elderly group (≥ 70 years of age) had the highest proportion (43.5%) of HTN. The prevalence of HTN was higher among males than females (male versus female: 25.4% versus 18%, $p < 0.001$). The highest prevalence of HTN was observed among those with no formal education (24.5%, $p < 0.001$), from the richest wealth quintile (28.3%, $p < 0.001$). Around a quarter of the Nepalese population in Province 3, Province 4, and Province 5, had HTN (24.9%, 28.8%, and 23.3%, respectively). The prevalence of HTN was higher in those 3 provinces than in other regions ($p < 0.001$). Considering the ecology of the habitat, the population in the hilly areas had the highest prevalence of HTN (24.2%, $p < 0.001$), compared to populations from other ecological regions. Higher prevalence was also observed among overweight/obese individuals (30.8%, $p < 0.001$) than other BMI categories (Table 1).

2. Age- and gender-specific prevalence of ISH, IDH and SDH

The age- and gender-specific prevalence of ISH, IDH, and SDH are presented in Table 2. Overall, 18.9% of the respondents

Table 1. Demographic characteristics of the respondents according to blood pressure status (n = 13,393).

Characteristics	Overall		Hypertensive blood pressure status				p
	N = 13,393		No (N = 10,566) +		Yes (N = 2,827) +		
	n	%	n	%	n	%	
Age (y)							< 0.001
18-29	4,337	32.4	4,071	93.9	266	6.1	
30-49	5,002	37.4	3,918	78.3	1,083	21.7	
50-69	3,188	23.8	2,087	65.5	1,101	34.5	
≥ 70	866	6.5	489	56.5	377	43.5	
Gender							< 0.001
Male	5,620	42.0	4,191	74.6	1429	25.4	
Female	7,773	58.0	6,375	82.0	1398	18.0	
Marital status							< 0.001
Never married	1,529	11.4	1,426	93.3	103	6.7	
Have been married	11,864	88.6	9,140	77.0	2724	23.0	
Education							< 0.001
No formal education	5,572	41.6	4,207	75.5	1365	24.5	
Primary	2,172	16.2	1,698	78.2	474	21.8	
Secondary	3,699	27.6	3,019	81.6	680	18.4	
Higher	1,950	14.6	1,641	84.2	309	15.8	
Household wealth status							< 0.001
Poorest	2,396	17.9	1,947	81.3	449	18.7	
Poorer	2,594	19.4	2,046	78.9	549	21.1	
Middle	2,666	19.9	2,191	82.2	475	17.8	
Richer	2,917	21.8	2,363	81.0	554	19.0	
Richest	2,820	21.1	2,019	71.6	801	28.4	
Place of residence							0.0147
Urban	8,191	61.2	6,360	77.6	1,831	22.4	
Rural	5,201	38.8	4,206	80.9	996	19.1	
Province							< 0.001
Province 1	2,365	17.7	1,889	79.9	475	20.1	
Province 2	2,748	20.5	2,308	84.0	440	16.0	
Province 3	2,933	21.9	2,202	75.1	732	24.9	
Province 4	1,380	10.3	982	71.2	398	28.8	
Province 5	2,184	16.3	1,675	76.7	509	23.3	
Province 6	674	5.0	565	83.9	109	16.1	
Province 7	1,109	8.3	945	85.2	164	14.8	
Ecological region							< 0.001
Mountains	856	6.4	701	81.9	155	18.1	
Hills	5,895	44.0	4,469	75.8	1426	24.2	
The Terai	6,642	49.6	5,395	81.2	1,246	18.8	
Body mass index							< 0.001
Normal weight	6,342	47.4	5,310	83.7	1,031	16.3	
Underweight	2,224	16.6	1,914	86.0	311	14.0	
Overweight/obese	4,826	36.0	3,342	69.2	1,485	30.8	

+ = row percentage.

Table 2. Age and gender specific prevalence of ISH- IDH- and combined systolic/diastolic hypertension in the adult Nepalese population.

Age (y)	Total hypertension (*n*)	Diagnosed and treated hypertension (%), 95% CI	Undiagnosed & untreated hypertension		
			SDH (%), 95% CI	ISH (%), 95% CI	IDH (%), 95% CI
	2,827	2.2 (1.9-2.6)	8.1 (7.4-8.9)	3.3 (3.0-3.7)	7.5 (6.9-8.1)
Male					
Age (y)					
18-29	143	0.7 (0.4-1.3)	1.7 (1.1-2.5)	5.3 (0.3-1.1)	6.0 (4.7-7.7)
30-49	557	1.5 (0.8-2.7)	11.7 (10.0-13.7)	1.0 (0.6-1.7)	13.2 (11.5-15.0)
50-69	540	4.2 (3.1-5.6)	17.0 (14.7-19.6)	6.8 (5.1-9.0)	7.3 (6.0-8.9)
≥ 70	189	7.4 (4.8-11.1)	13.2 (10.1-17.1)	18.5 (14.6-23.3)	3.0 (1.7-5.2)
Total	1,429	2.5 (1.9-3.2)	10.4 (9.3-11.6)	3.9 (3.2-4.6)	8.7 (7.9-9.6)
Female					
Age (y)					
18-29	122	0.2 (0.0-0.4)	0.8 (0.4-1.4)	0.1 (0.1-0.3)	3.5 (2.7-4.4)
30-49	527	1.5 (1.0-2.2)	5.5 (4.6-6.5)	1.0 (0.6-1.6)	9.7 (8.5-11.1)
50-69	561	5.0 (4.0-6.4)	14.9 (12.9-17.2)	7.1 (5.9-8.6)	6.8 (5.5-8.3)
≥ 70	188	6.1 (4.0-9.3)	16.2 (12.5-20.7)	19.7 (16.0-24.0)	3.1 (1.8-5.2)
Total	1,398	2.1 (1.7-2.5)	6.4 (5.8-7.2)	3.0 (2.5-3.5)	6.6 (5.9-7.3)

CI = confidence interval; SDH = systolic diastolic hypertension; ISH = isolated systolic hypertension; IDH = isolated diastolic hypertension.

had undiagnosed and untreated HTN. The prevalence of undiagnosed and untreated SDH, IDH, and ISH was 8.1% (95% CI: 7.4%-8.9%), 7.5% (95% CI: 6.9%-8.1%), and 3.3% (95% CI: 3.0%-3.7%), respectively. The prevalence was higher among males in all 3 sub-categories. In the case of undiagnosed and untreated SDH and ISH, the prevalence in both genders were higher among the older age-groups. However, in the case of undiagnosed and untreated IDH, the highest prevalence was observed in males and females aged 30-49 years.

3. Factors associated with undiagnosed and untreated HTN

The factors associated with undiagnosed and untreated HTN subtypes are described in Table 3. In the multivariate analyses, several demographic variables (e.g. age, gender), socioeconomic variables (e.g. education, province), and BMI were observed to have a statistically significant association with participants having ISH, IDH, or SDH, when adjusted for the potential confounders.

The odds of having undiagnosed and untreated SDH and ISH, were higher among the older age-groups, whereas for IDH it was younger ages. Gender was also statistically significantly associated with undiagnosed and untreated SDH and IDH. Being female was associated with a significantly reduced odds of having undiagnosed and untreated SDH (AOR 0.6; 95% CI: 0.5-0.7, $p < 0.001$) and IDH (AOR 0.6; 95% CI: 0.5-0.7, $p < 0.001$). Household wealth index was statistically significantly associated with undiagnosed and untreated SDH and ISH. A Nepalese adult from a poorer quintile household, had higher odds (AOR 1.3; 95% CI: 1.0-1.6, $p < 0.05$) of having undiagnosed SDH, compared with a person from the poorest quintile household. In contrast, being a person from the richest quintile household increased the odds of having undiagnosed ISH (AOR 1.8; 95% CI: 1.2-2.8, $p < 0.01$) compared with a person from the poorest quintile household. Residents of Province 4 had higher odds of having undiagnosed and untreated SDH (AOR 1.5; 95% CI: 1.0-2.2, $p < 0.05$) and IDH (AOR 1.5; 95% CI: 1.1-2.1, $p < 0.05$) compared to residents from Province 1. In addition, a resident of Province 5 had higher odds (AOR 1.6; 95% CI: 1.2-2.2, $p < 0.01$) of having undiagnosed and untreated IDH than a resident of Province 1. Being overweight/obese increased the likelihood of having undiagnosed and untreated SDH, ISH, and IDH. An overweight/obese individual was more likely to have undiagnosed and untreated SDH (AOR 2.2; 95% CI: 1.9-2.6, $p < 0.001$) and IDH (AOR 2.2; 95% CI: 1.9-2.6, $p < 0.001$)

Table 3. Unadjusted and adjusted odds ratios for factors associated with hypertension amongst adults in Nepal.

Characteristics	Undiagnosed & untreated SDH				Undiagnosed & untreated ISH				Undiagnosed & untreated IDH			
	COR	(95% CI)	AOR	(95% CI)	COR	(95% CI)	AOR	(95% CI)	COR	(95% CI)	AOR	(95% CI)
Age (y)												
18-29	Ref		Ref		Ref		Ref		Ref		Ref	
30-49	9.1***	(6.7-12.3)	7.2***	(5.1-10.2)	4.6***	(2.4-8.8)	4.6***	(2.2-9.6)	3.1***	(2.6-3.6)	2.4***	(1.9-2.9)
50-69	22.3***	(16.5-30.3)	19.7***	(13.7-28.2)	39.6***	(21.5-73.0)	42.9***	(20.9-88.1)	2.5***	(2.1-3.1)	2.3***	(1.8-3.0)
≥ 70	28.5***	(20.0-40.6)	29.4***	(19.4-44.6)	144.6***	(77.0-271.4)	166.5***	(78.7-352.4)	1.41	(1.0-2.2)	1.6*	(1.0-2.5)
Gender												
Male	Ref		Ref		Ref		Ref		Ref		Ref	
Female	0.5***	(0.5-0.6)	0.6***	(0.5-0.7)	0.7***	(0.6-0.8)	0.9	(0.7-1.2)	0.6***	(0.6-0.7)	0.6***	(0.5-0.7)
Marital status												
Never married	Ref		Ref		Ref		Ref		Ref		Ref	
Have been married	6.2***	(4.2-9.2)	1.0	(0.6-1.6)	6.4***	(3.4-12.1)	0.6	(0.3-1.3)	2.8***	(2.1-3.8)	1.5*	(1.1-2.1)
Education												
No formal education	Ref		Ref		Ref		Ref		Ref		Ref	
Primary	0.7***	(0.6-0.8)	0.9	(0.8-1.2)	0.4***	(0.3-0.6)	1.1	(0.7-1.5)	1.3*	(1.0-1.5)	1.1	(0.9-1.4)
Secondary	0.5***	(0.4-0.5)	1.0	(0.8-1.2)	0.2***	(0.1-0.3)	0.9	(0.6-1.3)	1.1	(0.9-1.3)	1.1	(0.9-1.4)
Higher	0.3***	(0.3-0.4)	0.9	(0.6-1.2)	0.1***	(0.1-0.2)	0.8	(0.4-1.4)	0.9	(0.8-1.2)	1.1	(0.9-1.5)
Household wealth status												
Poorest	Ref		Ref		Ref		Ref		Ref		Ref	
Poorer	1.21	(1.0-1.5)	1.3*	(1.0-1.6)	1.0	(0.7-1.3)	1.1	(0.8-1.5)	1.1	(0.9-1.4)	1.1	(0.8-1.4)
Middle	1.0	(0.8-1.3)	1.1	(0.9-1.5)	0.8	(0.6-1.1)	0.9	(0.6-1.4)	1.0	(0.8-1.3)	1.0	(0.8-1.3)
Richer	1.1	(0.8-1.3)	1.1	(0.8-1.4)	0.9	(0.7-1.3)	1.1	(0.8-1.6)	1.21	(1.0-1.5)	1.1	(0.8-1.4)
Richest	1.4***	(1.1-1.9)	1.2	(0.9-1.7)	1.31	(0.9-1.7)	1.8**	(1.2-2.8)	1.6***	(1.3-2.0)	1.1	(0.8-1.5)
Place of residence												
Urban	Ref		Not included in the final model		Ref		Not included in the final model 0.8*		Ref		Ref	
Rural	0.9	(0.7-1.1)	0.9		(0.7-1.1)		(0.7-1.0)		0.9	(0.8-1.1)		
Province												
Province 1	Ref		Ref		Ref		Ref		Ref		Ref	
Province 2	0.7*	(0.5-1.0)	0.8	(0.6-1.2)	0.8	(0.6-1.2)	0.9	(0.6-1.5)	1.0	(0.7-1.3)	1.2	(0.9-1.8)
Province 3	1.31	(0.9-1.8)	1.1	(0.7-1.6)	1.0	(0.7-1.4)	0.8	(0.5-1.2)	1.7**	(1.2-2.2)	1.4	(1.0-1.9)
Province 4	1.8***	(1.3-2.5)	1.5*	(1.0-2.2)	1.41	(1.0-2.1)	1.4	(0.9-2.2)	1.8***	(1.3-2.4)	1.5*	(1.1-2.1)
Province 5	1.2	(0.9-1.7)	1.3	(0.9-1.9)	1.3	(0.9-1.8)	1.5	(1.0-2.2)	1.5*	(1.1-2.0)	1.6**	(1.2-2.2)
Province 6	0.7*	(0.5-0.9)	0.8	(0.5-1.2)	0.6*	(0.4-1.0)	0.8	(0.5-1.4)	1.31	(0.9-1.7)	1.3	(0.9-1.9)
Province 7	0.6**	(0.4-0.8)	0.7	(0.5-1.0)	0.71	(0.5-1.1)	0.8	(0.5-1.2)	0.9	(0.6-1.2)	1.1	(0.8-1.5)
Ecological region												
Mountains	Ref		Ref		Ref		Ref		Ref		Ref	
Hills	1.8**	(1.2-2.7)	1.4	(0.9-2.2)	1.51	(0.9-2.3)	1.2	(0.7-2.1)	1.4*	(1.0-2.0)	1.2	(0.8-1.7)
The Terai	1.2	(0.8-1.8)	1.1	(0.7-1.7)	1.3	(0.8-2.1)	1.1	(0.6-2.0)	1.0	(0.7-1.5)	0.9	(0.6-1.4)
Body mass index												
Normal weight	Ref		Ref		Ref		Ref		Ref		Ref	
Underweight	0.8*	(0.6-1.0)	0.6***	(0.5-0.8)	1.5**	(1.2-2.0)	0.9	(0.7-1.2)	0.6***	(0.4-0.7)	0.6***	(0.5-0.8)
Overweight/ obese	2.2***	(1.9-2.6)	2.2***	(1.9-2.6)	1.5**	(1.2-1.8)	1.6***	(1.2-2.1)	2.5***	(2.2-2.9)	2.2***	(1.9-2.6)

[1] $p < 0.2$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
Variable with $p < 0.2$ from unadjusted model were included into multivariate analysis STROBE 2007 (v4) Statement- Checklist of items that should be included in reports of cross-sectional studies.
ANC = antenatal care; AOR = adjusted odds ratio; CI = confidence interval; COR = crude odds ratio; ACC/AHA = American College of Cardiology/American Heart Association; SDH = systolic diastolic hypertension; ISH = isolated systolic hypertension; IDH = isolated diastolic hypertension.

compared to an individual of normal body weight. In contrast, being underweight reduced the odds of having undiagnosed and untreated SDH (AOR 0.6; 95% CI: 0.5-0.8, $p < 0.001$) and IDH (AOR 0.6; 95% CI: 0.5-0.8, $p < 0.001$) statistically significantly compared to an individual with a normal body weight.

Discussion

To the best of our knowledge, this was the first study from Nepal to identify the prevalence, and factors associated with undiagnosed and untreated ISH, IDH, and SDH among the adult population in Nepal. Around one-fifth of the adult Nepalese population was suffering from undiagnosed and untreated HTN. The prevalence of IDH and SDH were high followed by ISH. In both males and females, the prevalence of SDH and ISH increased with age. On the other hand, IDH was more prevalent in the 30-49 years age group. Age, gender, marital status, household wealth status, province of residence, and BMI was associated with HTN subtypes.

The findings of this study were consistent with the studies conducted on HTN subtypes in other developing nations [8,11,37,38]. The prevalence of ISH was similar to the reported prevalence from neighboring Northern India (male: 5.1%; female: 3.6%) and Bangladesh (male: 3.0%; female: 4.7%) [8,38]. On the other hand, it was lower than the reported prevalence of ISH in China (7.6%) [37]. The reported IDH prevalence (7.5%) in this current study was higher than the reported prevalence from Bangladesh (5.2%) and India (4.5%) [8,11]. The SDH prevalence (8.1%) was also higher than the reported prevalence from Bangladesh (5.2%) [8]. Differences in measurement methods may impair direct comparison between studies. The higher prevalence estimates in China may be attributed to the increased westernization compared with its neighboring counterparts [37]. When comparing between studies it should be noted whether a study is regional or national. There is a paucity of nationwide data in terms of prevalence of undiagnosed IDH in India. Kanpur, being an industrial city has better health-care and diagnostic systems, hence a lower estimate of the prevalence of undiagnosed IDH is observed [11]. The Bangladeshi study included an adult population aged ≥ 35 years, whereas the current study included individuals aged ≥ 18 years [8]. This could explain the higher prevalence of IDH in Nepal than that of Bangladesh and India.

The prevalence of ISH and IDH increased and decreased respectively, with increasing age in this current study. Increasing age was observed to be associated with undiagnosed and untreated ISH and SDH. Age is a non-modifiable risk factor of HTN subtypes [39]. With increasing age, and arterial stiffness increases, resulting in a higher prevalence of elevated BP [40]. Previous evidence showed that between the age of 30-84 years, the prevalence of SBP increases [41]. The prevalence of IDH was the highest among the 30-49 years age group. The odds of IDH decreased with increasing age. This is because diastolic DBP increases up to the age of 50 years due to increased peripheral vascular resistance in small blood vessels, and then gradually decreases [40,41].

Being male was positively associated with SDH and IDH. Aryal et al [42] reported a higher prevalence of smoking, physical inactivity, high blood sugar, and total blood cholesterol among Nepalese males, compared to their female counterparts [42]. Smoking, physical inactivity, high blood sugar, and total blood cholesterol were major risk factors, which increase arterial stiffness and contributed to HTN [43-46]. The findings in this current study do not align with a similar study performed in neighboring Bangladesh, where being female was reported to be a major associated factor for HTN subtypes [8].

Like the previous studies on HTN performed in Nepal, this current study did not show any consistent relationship patterns between wealth index and HTN subtypes [47,48]. In this study, only the richest wealth index showed a positive association with SDH. People of the richest households tended to have a higher calorific intake, which was compounded with the increased likelihood of leading a sedentary lifestyle, and developing SDH [49].

Residence in Province 4 (later officially renamed Gandaki Pradesh) was positively associated with ISH and IDH. In addition, residence in Province 5 also showed a positive association with IDH. This provincial difference in the associated factors of HTN has been observed in Nepal [26,50]. Regional variations due to differences in socioeconomic conditions and dietary habits have been previously observed in other countries. For Nepal in particular, such disparities led to substantial regional differences in health status [51,52]. Although the higher odds of undiagnosed and untreated IDH in Province 4 and 5 could be attributed to such regional differences of societal and population characteristics, this was beyond the scope of analysis in this current study. Further studies are needed to understand why the prevalence of ISH and IDH was higher in these provinces.

This current study observed that being overweight or obese was positively associated with all of the HTN subtypes, an association previously reported [8,53]. The BP of obese individuals increases due to sympathetic activation, structural changes in the kidney, impairment of pressure natriuresis, and impairment of the renin-angiotensin system, which are further coupled with a high level of circulating insulin, corticosteroid, leptin, and neuropeptides [54]. HTN prevention, and control programs in Nepal should focus on overweight and obese individuals for targeted high-risk approaches.

This study has several notable strengths. The findings of the study are generalizable to the Nepalese people, as a

nationally representative sample was analyzed. Due to the utilization of standard and validated tools, the possibility of measurement error was less than other equivalent studies performed in Nepal. The limitations of this study include the causal relationship between the independent and outcome variables which could not be established due to the cross-sectional nature of the study. BP was measured in a single visit, although the standard guidelines recommended longitudinal measurement [27,52]. The relationship between several HTN subtypes with lifestyle factors (dietary habits and physical activities), and smoking could not be evaluated as the NDHS 2016 did not collect data on those variables.

Conclusion

This study observed a high prevalence of undiagnosed and untreated HTN subtypes in the adult Nepalese population. Given the public health importance of these conditions, necessary steps (including awareness against the known risk factors, promotion of physical activity and healthy diet) should be taken by public health promotion programs in Nepal. People who are older, male, overweight or obese, who have a higher socioeconomic condition and are residents of Province 4 (Gandaki Pradesh) or Province 5, had a higher likelihood of suffering HTN and should be enrolled in HTN prevention and control programs.

Conflicts of Interest

The authors report no conflicts of interest.

Acknowledgments

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Appendix A. Prevalence and associated factors of hypertension subtypes among the adult population in Nepal: Evidence from the Demographic and Health Survey data.

Section/Topic	Item#	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	8-9
Study size	10	Explain how the study size was arrived at	8-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	8-9
		(b) Describe any methods used to examine subgroups and interactions	8-9
		(c) Explain how missing data were addressed	Not applicable
		(d) If applicable, describe analytical methods taking account of sampling strategy	8-9
		(e) Describe any sensitivity analyses	Not applicable

Appendix A. (Continued).

Section/Topic	Item#	Recommendation	Reported on page #
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed	9-10
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	9-10
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	9-12
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-12
		(b) Report category boundaries when continuous variables were categorized	9-12
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses performed e.g. analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarize key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalizability	21	Discuss the generalizability (external validity) of the study results	14-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.